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THE OFFICIAL ORGAN OF THE ASSOCIATION OF ECONOMIC BIOLOGISTS

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VOLUME IV SEPTEMBER, 1917 Nos. 1 and 2

FRIT FLY (*OSCINUS FRIT*) ATTACKING WINTER WHEAT.

BY F. R. PETHERBRIDGE.

(*School of Agriculture, Cambridge.*)

From enquiries sent in during the past three years, there is little doubt that in addition to the damage it does to late sown spring oats, the "frit fly" must also be reckoned as a pest of winter wheat in this country. Several observers have recorded this fly as attacking winter wheat on the continent.

The first enquiry was received in March, 1914, from Mr C. J. Littlewood, Whitwell Hall, Skeyton, near Norwich. Specimens of dead and dying wheat plants were sent in and in these the larvae of the "frit fly" were found. Unfortunately the wheat was ploughed in just after the plants were sent, but this will serve to show that the damage done must have been considerable. This wheat was sown about December 1st.

On March 1st, 1915, an enquiry was received from Mr H. V. Sheringham, Blue Stone Farm, South Creake, Norfolk. Here 54 acres of wheat were sown on November 11th—15th, receiving a dressing of farmyard manure, and following a crop of Rye Grass and Clover. Mr Sheringham writes as follows: "The wheat was slow in coming up owing to excessive rain." Although about 20 % of the plants were attacked by the larvae of the "frit fly" the wheat tillered well in the spring and produced a fair crop (about 32 bushels per acre).

In 1916, an enquiry was received from Messrs Tayton, White Hall Farm, Syderstone, Norfolk, concerning fields quite near to Mr Sheringham's farm.

Three fields were badly attacked by the larvae of the "frit fly," their previous cropping being:

	1911	1912	1913	1914	1915	1916
32 acres	Oats	Turnips	Barley	Italian Rye Grass and Suckling Clover	Seeds mixture left down	Wheat
48 „		Wheat	Turnips	Barley	Perennial Rye Grass and Red Clover	Wheat
12 „		Wheat	Turnips and Kale	Barley	Italian Rye Grass and Suckling Clover	Wheat

The wheat was sown on Oct. 14th—20th and received 10 loads of farmyard manure per acre.

On all these fields about 25 % of the plants were attacked when examined on February 9th. No attack of "frit fly" was noticed in the spring corn of 1915.

Neighbouring fields of wheat were visited and "frit fly" larvae were found in all cases.

A field of rye joining a field of badly attacked wheat was apparently free from "frit fly."

In December, 1912, and January, 1913, Edmunds[1] found "frit fly" larvae in Rye Grass in a clover ley and also in Golden Oat Grass (*Avena flavescens*) and in False Oat Grass (*Arrhenatherum avenaceum*).

Baranov has also recorded the spring generation of flies as laying eggs on the following grasses: *Phleum pratense, Alopecurus pratensis, Lolium perenne, Triticum cristatum, Festuca pratensis, Avena flavescens* and *Poa pratensis.*

The writer also found "frit fly" larvae on Italian Rye Grass (*Lolium italicum*) on March 6th, 1916.

In this connection it is interesting to note that the above attacks are all after crops of Rye Grass or Italian Rye Grass.

The 18 acre field was ploughed up on May 1st—3rd and sown with Barley on May 4th which on threshing showed a yield of 36 bushels per acre. The other two fields were left and yielded about 20 bushels of wheat per acre. It will be seen from this that the "frit fly" is capable of causing a considerable reduction in the yield of winter wheat.

On February 21st, 1913, a sample of Winter Oats and Vetches was received from Wickham Market, Suffolk, and in the Oats larvae of the "frit fly" were found. This crop followed a crop of late-sown spring oats and was sown on October 12th.

The above observations are interesting in connection with the life history of the "frit fly."

Mr Littlewood's wheat was sown about December 1st and Mr Sheringham's wheat which was not sown until November 14th was slow in coming up. If the "frit fly" has only three broods in a year we should have expected the wheat to be safe from an attack under these conditions. Is this attack of winter wheat caused by the third brood of flies which hatch out from the pupae in the ears of oats or from those in the shoots of cereals or grasses (usually in September), or is it a fourth brood? In this connection the following may be of interest:

[1] *Joint Report, Harper Adams College,* 1912.

In a sample of spring wheat from Chaul End, near Luton, sown the third week in April, 1916, three larvae and two empty pupa-cases of the "frit fly" were found on October 3rd. (Other larvae very similar to those of "frit fly" but not yet identified were also found.) This crop was also badly attacked by the "Hessian Fly" *Cedidomyia* (*Mayetiola*) *destructor* and a number of young tillers were present as is usual in late-sown spring wheat.

Hitherto three broods of the "frit fly" have been recognised.

Brood 1 appears in April and May and lay their eggs on spring corn.

Brood 2 appears in July and lay their eggs on the ears of oats or barley or on the shoots of cereals and grasses.

Brood 3 appears in August and September and lay their eggs on the shoots of grasses or *early-sown* winter corn.

Without further knowledge of the life history it is difficult to account for the above attacks on winter wheat.

Among the possibilities which would account for these late attacks of winter wheat are the following:

(1) The third brood of flies may hatch out over a very long period and the last ones lay their eggs on winter wheat.

(2) Some of the third brood of flies may be capable of living until December before laying their eggs.

(3) The larvae of the third brood of flies may under certain conditions give rise to a fourth brood of flies which lay their eggs on winter wheat.

(4) In a letter Fryer suggests that "The third brood of flies may migrate from the plants on which they hatched to the wheat which is sown after the former host plants are ploughed in."

Cases 1, 2 and 3 seem rather improbable as it would necessitate the emergence of the fly in cold weather of which at present there is no record.

Case 4 seems more probable as several observers have found "frit fly" larvae in the shoots of grasses and it is quite possible that migration takes place from these plants to the wheat. This would also account for the absence of the adult fly in the winter months.

It will be seen from the above that more knowledge of the life history of the "frit fly" is needed in order to find out the most efficient means of reducing attacks on winter wheat. We know that early-sown spring corn in a good seed bed usually escapes attack, but as the fly can lay its eggs on grasses there is always the danger that our winter wheat will be attacked even if we sow our spring corn early.

SOME FARM INSECTS OBSERVED IN THE ABERYSTWYTH AREA, 1913–1916.

By C. L. WALTON, M.Sc.

(Departments of Agriculture and Zoology, University College of Wales, Aberystwyth.)

The following insects were collected and observed during the progress of a Survey of Agricultural Zoology which I recently carried out in the Aberystwyth Area.

The area examined comprised some 250 sq. miles, and included the Plynlymon mountain mass; the wooded river valleys and foot hills; the wide peat bog bordering the southern bank of the Dyfi Estuary; the cultivated region of hill and valley about the coast and lower reaches of the rivers Rheidol and Ystwyth; and a region of high, bare, ill-drained hills (largely coated with boulder clay) lying to the S.E. and within the Teifi watershed. The predominant features of the whole include slaty and grit rocks, overlaid to a very large extent by peat and boulder clay; a moist climate; an Agriculture in which sheep farming predominates, followed in order by cattle raising, dairying and horse breeding. Corn and root growing are seldom more than subsidiary in value; while fruit growing hardly exists; and market gardening, to a limited extent, around Aberystwyth only.

During the progress of the Survey little attention was paid to any gardens other than those of the farmers, and in the mountains few farms can boast a garden worthy of the name. In many groups the lists are by no means complete, the scope of the Survey was a wide one, and special attention was given to the Liver Rot of sheep. The work was carried out under a grant from the Board of Agriculture and Fisheries.

Cabbage Butterflies.

Early in September, 1914, I left Aberystwyth and travelled down the coast of Cardigan Bay (chiefly on foot) into Pembrokeshire and visited several parts of that county. Up to the time of leaving the Survey

Area I had not received any complaints or noted any unusual abundance of the larvae of the White Butterflies, and my attention was first drawn to an attack upon Swedes and Rape in adjacent fields upon a cliff farm near Fishguard. Subsequently I saw others, while Cabbages were, in many places reduced to mere skeletons. I returned to Aberystwyth by train and noted some damaged Swedes as soon as the Survey Area was entered. I made about 40 enquiries, and discovered that whilst not so severe as in S.W. Wales, these pests were sporadically abundant within the Area. Following these enquiries I visited a number of the places whence damage was reported.

The larvae of *Pieris brassicae* and *P. rapae* damaged garden Crucifers, and to a lesser extent Swedes from sea level to 1100 feet. The damage to Broccoli and Sprouts, however, was not equally distributed; steep banks lying in the sun; the upper parts of fields and similar hot, dry situations suffered most, while gardens and fields in damp situations, near rivers, etc., were least affected.

Two of the more severe cases were reported from mountain valleys; one from the upper portion of the Ystwyth (about 700 feet) following a swarm of butterflies which were noted about the Swedes at the end of August; the other from the steep slopes of the Rheidol valley. This latter was visited when the Swedes were being harvested, and there was little difference in size between the roots from the upper half of the field which had been badly stripped, and the lower which was but lightly attacked, the damage having being done too late to seriously affect growth. Both in Pembrokeshire and in the Aberystwyth Area farmers reported that broadcasting lime and soot had been without effect. Within the Survey Area one farmer tried dusting with Basic Slag after a shower (on Swedes) and another had no success with a dressing of Baking Powder applied to cabbages!

Mr D. J. Morgan the Agricultural Organiser for Cardiganshire informed me that he had observed Keating's powder (Pyrethrum) used upon Cabbage with excellent results. Commencing on September 28th I experimented upon several rows of Cabbages in an Aberystwyth garden; dusting with lime produced little results, and watering with brine practically none, but a dusting of Pyrethrum was rapidly effective.

A large proportion of the larvae in Aberystwyth gardens were parasitised, and quite half the larvae and pupae observed attached to walls, etc., in early October showed the yellow cocoons of the Braconid, *Microgaster glomeratus*.

During September and October, 1915, I noted slight damage to

Swedes in two instances, in each case the margins of the fields being affected, but no serious outbreak followed the unusual abundance of 1914.

In 1916 a number of the larvae of *P. brassicae* were present upon Swedes near Crosswood at the end of July, and upon Cabbage in gardens during September, and the parasite above mentioned was again in evidence, especially about Aberystwyth.

Flea Beetles.

I received fifty complaints of damage to root crops by Flea Beetles and investigated a large number of these.

Two species are present, *Haltica nemorum* and *H. oleracea*. The former is generally the more abundant and at times is locally predominant, but usually both are present, and often in about equal proportions. These pests appear to be always present, and only await the advent of the needful crop and weather conditions in order to multiply and work havoc. Dry weather and sunshine are essential to these beetles and heavy rain either ends, or very much limits their ravages.

Young root crops on dry slopes, hillsides and banks are usually the worst damaged, but I have seen considerable harm done in low fields as well.

Should adverse conditions delay growth the damage done is generally aggravated, the continuance of conditions favouring the pests may result in the first sowing of seeds failing entirely, while even a second may be damaged.

It is notable that comparatively few complaints are heard from farms where lime and basic slag are regularly used. On many farms it is usual to give a dressing of quick lime prior to sowing the root crop.

During July, 1915, I noted a slight attack on mangolds. The situation was high and sunny, and it was evident that the Swedes having made a very vigorous growth, the beetles had migrated to the contiguous rows of mangolds, of which, however, only the two nearest rows were affected. In 1916, mangolds were severely attacked, and in a number of instances the crop was considerably reduced. In one case roots had not been grown upon the field within local memory, two crops of oats having followed an old rough pasture, prior to the root crop. Damage continued in this field up to mid July, and included successively mangolds, swedes and turnips. *Polygonum persicaria* was a common weed in this field (and often abounds in mountain root fields) and was also badly riddled by the beetles.

Soaking seed in paraffin has proved of benefit. One farmer broad-

casted basic slag upon a badly infected patch without obvious benefit and two others remembering the customs of their grandfathers dragged branches of Elder (Ysgawn) over their fields, but, as one of them said, "only made 'em hop."

Apple Weevil, *Anthonomus pomorum*, Lin.

The Apple Weevil occurred in some abundance in May, 1914, upon apple blossom in a farm garden three miles S. of Aberystwyth. A considerable number of apples had been planted about the house and buildings and latterly somewhat neglected. The beetle was also present upon crab apples in the same vicinity, but whether the pest was introduced with the apples or was endemic upon the crabs it is not possible to say; but probably the former. I have since found this weevil in one or two other gardens, all far apart.

Clover Weevil, *Apion apricans*, Herbst.

The Clover Weevil was seen in some abundance in July, 1916, among hay crops when being harvested, near Crosswood, and several were obtained on pasture fields while gathering mushrooms in September in the same locality.

Wireworms, *Agriotes* sps.

Thirty-two farmers and several gardeners complained of wireworm attack in varying degrees of severity. Oats, wheat, swedes and potatoes were the crops involved, but principally oats and swedes.

As mentioned under flea beetles, farmers who make a free use of lime, basic slag, kainit, etc., seldom complain of these larvae. Almost all the worst attacks were in the second successive crops of oats following old, and often "foggy" pastures; the damage to the first crop being either slight or not recognised, and there is no doubt that many of these outbreaks could be avoided, by care and observation.

The majority of the affected fields are situated on sunny hill-sides, where the soil is shallow and dry. Many of the complaints (and almost all relating to swedes) came from the S.W. region of the Area surveyed, —named by myself the "Coastal Uplands," and most of the cases of young swedes being pulled up by rooks are due to the energetic search for the larvae by these birds.

Notwithstanding the abundance of the larvae, I have found it difficult to obtain more than odd specimens of the adult beetles and hence cannot say anything about the relative distribution of the species.

Several farmers harrowed in a dressing of soot and subsequently rolled, with excellent effect, while both kainit and lime have proved their value.

On some farms about 15 cwt. per acre of ground lime mixed with the surface soil during the preparation for roots, helps greatly to clear the land of these pests.

Plain rolling, although doubtless of assistance, seldom effects a cure on the light stony soils.

One farmer experimented with plots as follows:

1. Rolling every other day.
2. Applied soot and then rolled.
3. Applied salt and rolled.
4. Applied a dressing of nitrate of soda.

No. 2 proved most effective, followed in order by 4. This man noted a daily advance of two yards by these larvae, he now controls any patches that appear by the use of soot, harrow, and roller.

The value of basic slag in controlling *Agriotes* larvae was noted by Umnov in 1914. Part of a field manured with superphosphate was injured, while a neighbouring part manured with basic slag was not attacked[1].

Chafer Beetles, *Phyllopertha horticola*, Lin., etc.

I have never seen a single specimen of the common Cockchafer (*Melolontha vulgaris*) within the Area, except about the town of Aberystwyth; and of *Cetonia aurata*, the Rose Chafer, one complaint of damage to rambler roses reached me. From the appearance of the foliage and the description given it is probable that that insect was the cause.

P. horticola. The so-called Garden Chafer, however, is locally exceedingly abundant at times. It is typically an inhabitant of the "slope land," and swarms about the dry sunny sides of the mountain valleys. The adults were very abundant in June, 1915, especially in the Northern valleys, and in August—September the larvae abounded in the pasture lands of these slopes. Rooks and other birds assembled upon these places in hundreds and in their search for the grubs literally dug up acres of the already loosened herbage. Notwithstanding their efforts a considerable number of larvae remained; but there is no doubt that this Chafer is largely controlled by these birds. Further

[1] A. Umnov. Report on the Work of the Entomological Bureau of Kaluga, 1913. (Abstract from the Russian, in *Review of Applied Entomology*, April, 1914.)

examination in March and September, 1916, showed that these pastures had largely recovered by the latter date. I have heard the term *Chwilen y rhedyn* or fern beetle applied to this insect in the Llyfnant Valley, where also I was informed that it had damaged garden apples.

Aphides.

I am indebted to Prof. F. V. Theobald, M.A., of the South Eastern Agricultural College, Wye, for the identification of all the species here recorded with the exception of *S. lanigera*, *R. ribis* and *M. cerasi*. Apart from these and *A. rumicis*, none are of economic significance agriculturally.

With regard to the above species *Rhopalosiphum ribis* is seldom common and little fruit is grown in the Area apart from private gardens.

Aphis rumicis sometimes occurs in numbers upon mangolds, and in 1915 I noted it abundantly upon *Atriplex patula* growing among mangolds on July 1st. A watch was kept, but none were observed upon the mangolds until July 7th when migration commenced. In 1916 this pest was scarce, and I only obtained a few from Docks in July and August, and a very few on Broad Beans in early September. This species was so abundant upon Broad Beans in 1915 that a large proportion of the crop failed completely, the plants presenting a stunted and scorched appearance. Beans are not grown as a field crop within the Area, only a few rows being seen, here and there. Even in gardens the practice of "topping" is practically unknown, and hence no check is given to the pest. During 1916 this insect was also as infrequent on beans as on mangolds.

Macrosiphum granarium was found upon black oats near Crosswood during July, 1915, but not in sufficient abundance to make any difference to the health of the crop.

Schizoneura lanigera. This species is to be found practically wherever apples are grown but generally in small amount. With certain exceptions, the farmers of the Area give but little attention to gardening, especially those living at high elevations. Market gardening could, in certain parts, be practised to a much greater degree.

The following is a list of recorded species, together with their host plants:

Phylloxera quercus, Fons. Oaks in hedge, abundant at Crosswood, Aug. 1916.

Schizoneura lanigera, Hausmann. Apple.

Callipterus quercus, Kaltenbach. Crosswood, 1915. Collected on Oats, but probably came from an Oak near by.

Aphis pruni, Reaumur. Damsons.

A. rumicis, F. Beans, Mangolds, Docks and *Atriplex*.

A. cardui, Lim. *Carduus arvensis*. 1916.

A. urticaria, Kalt. Nettles. Crosswood.

A. loti, Kalt. *Lotus* sp. Crosswood.

A. gossypii, Glover. A Cucumber grown in the open was killed by this insect. Crosswood, July, 1916.

A. hederae, Kalt. *Aralia sieboldii*. Aberystwyth.

Rhopalosiphum ribis, L. Garden Currants.

R. lactucae, Kalt. *Sonchus oleraceus*.

Macrosiphum rosae, L. Rambler Roses, also on Dog Rose in hedges.

M. jaceae (L.). *Centaurea niger* and *Lychnis diurna*.

M. lactucae, Kalt. Lettuce. Aberystwyth.

M. granarium, Kirby (*M. cerelis*, Kalt). Oats, July, 1915.

M. absinthii, L. Wormwood. Crosswood, July, 1916.

M. pseudorubiellum, Theobald. Brambles. Crosswood, July, 1916. A species recently described.

Myzus cerasi, Fabricus. Cherry (on wall). Llanfarian.

M. circumflexus, Buckton. Cineraria. Pontrhydgroes.

Amphorophera rubi, Kalt. Brambles.

Also several others not yet correctly determined.

Scale Insects.

Scale insects are not at all common within the Survey Area, with the exception of *Chionaspis salicis*, L., which is common upon Ash, Birch and various species of Sallow (*Salix*) from sea level to the upward limit of the tree growth.

Lepidosaphes ulmi (*Mytilaspis pomorum*) is to be found in some gardens, but very seldom in any abundance. It does not occur in such a manner as to suggest that it is native in the Area, and would appear to have been introduced with nursery stock. It was abundant on apples in one garden in Aberystwyth and upon a pear trained against a wall in another. Elsewhere it only occurred in very small numbers and then usually upon young isolated trees.

Lecanium persicae (Geoffrey) has been sent me twice from private gardens and *L. capreae* (L.) once from a similar situation.

Nine species were obtained from indoor and green-house plants

chiefly about Aberystwyth and the experimental green-house of the Botany Department of the University: these nine were as follows:

1. *Aspidiotus hederae*, Vallot. On a pot palm.
2. *A. cyanophylli*, Signoret. Leaves of *Cycas revoluta*.
3. *Fiorinia fioriniae*, Targioni-Tozzetti. Palm, with *A. hederae*.
4. *Diaspis zamiae*, Morgan. Upon ♀ sporocarp (megaspore) of *Dioon edule*.
5. *Chionaspis aspidistrae* (Signoret). Ferns.
6. *Lecanium hesperidum* (L.). Common upon pot ferns.
7. *L. perforatum* (Newstead). Palm.
8. *L. hemisphericum* (T. T.). On *Macrozamia spiralis*.
9. *Dactylopius longispinus* (T. T.). Vines; beneath scales of *Cycas revoluta*; and larvae beneath leaves of *Dorstenia* sp.

Cecidomyidae.

Only two have been noted as harmful.

Perrisia crataegi (Winn), which affects the tips of young Hawthorn shoots causing them to assume the appearance of a rosette. This insect is common, and affects a considerable proportion of the shoots in the lowlands.

The second species is *Rhabdophaga salicis* (Schrank) which I have obtained galling species of *Salix* on the banks of the Ystwyth, near Aberystwyth, and elsewhere; it is not at all abundant.

Crane Flies, *Tipulidae*.

I have only recorded three species, although others undoubtedly exist, one of which was very abundant on the Dyfi Flats in 1914; the specimens then collected were, however, unfortunately lost. *Tipula oleracea*, Lim., is at times very common, but only one complaint concerning it reached me, specimens being sent in 1913 by Sir E. Pryse, Bart.; the larvae were exceedingly abundant in one of his fields at Gogerddan. *T. lateralis*, Meig., was fairly common in 1916, and *Pedicia rivosa*, L., was obtained on mountain pastures.

Onion Fly, *Phorbia cepetorum*, Bouché.

The Onion Fly was noted several times from leeks. In October, 1915, in a farm garden near Borth, a bed of leeks 40 × 15 feet in extent was destroyed, only about a dozen plants remaining when I visited the place on November 4th. From 3 to 7 larvae were obtained from each of these leeks.

MANGOLD FLY, *Pegomyia hyoscyami*, Panz. (*P. betae*, Curt.).

The Mangold Fly. I have never seen young Mangolds attacked, nor any appreciable damage done, but a few brown blisters are to be seen now and again. I have failed to obtain the adult fly.

PIOPHILA CASEI.

I observed this fly in hundreds in one farm house, and obtained the larvae from bacon and hams that were hanging from the ceiling of the kitchen. These maggot-like larvae can "skip" freely, and do not seem to harm the bacon to any great extent, since no foul or decayed place could be found even where the larvae were feeding.

LIPURA AMBULANS, L.

This minute Apterous insect was observed in November, 1915, in large numbers upon leeks in a farm garden near Borth. The leeks had been very severely attacked by the Onion Fly (*P. cepetorum*). Some adjacent carrots were also attacked, but were not seriously injured. The same pest was obtained damaging the seeds of French Beans sown in an Aberystwyth, garden in the Spring of 1916. *Sminthurus luteus*, Lubbock, was fairly common upon field mushrooms at Crosswood in September, 1916. Several other related species were observed in small numbers.

ANTS.

Time did not allow of a full study of many groups of subsidiary interest, and I am chiefly indebted to Mr F. S. Wright of the Zoology Department, Aberystwyth, for the following identifications of Ants collected during the course of the Survey.

The nomenclature is that of Donisthorpe, *British Ants*, 1915.

1. *Monomorium pharaonis*, L.
2. *Myrmica laevinodis*, Nyl.
3. *M. ruginodis*, Nyl.
4. *Formica rufa*, L.
5. *F. fusca*, L.
6. *F. rufibarbis*, F.
7. *F. picea*, Nyl.

All the above records refer to workers.

F. fusca seems to be the most widely distributed, and has been taken from sea level to 1000 feet.

M. pharaonis was only obtained from the town of Aberystwyth where it was causing annoyance in a bakery and also in a tobacconist's shop.

F. rufa is confined to woodlands containing an admixture of Coniferae.

Wasps.

These insects are usually fairly abundant, but were peculiarly scarce in 1916, although queens were plentiful during the spring and I obtained specimens of *Vespa vulgaris*, *V. germanica*, and *V. rufa*; the two former commonly. Old nests of *V. sylvestris* have been observed but I have not taken the insect.

Humble Bees, *Bombi*.

I am indebted to Mr T. Alan Stephenson for the following notes on the *Bombi* and *Psithyri* of the Aberystwyth Area.

At my suggestion he gave considerable attention to these groups during 1915–16.

Twelve species of *Bombus* and five of *Psithyrus* have occurred, namely:

1. *Bombus lapidarius*, Linn.
2. *B. terrestris*, Linn.
3. *B. lucorum*, Linn.
4. *B. soröensis*, Fab.
5. *B. pratorum*, Linn.
6. *B. jonellus*, Kirby.
7. *B. lapponicus*, Fab.
8. *B. hortorum*, L.
9. *B. derhamellus*, Kirby.
10. *B. sylvarum*, L.
11. *B. agrorum*, Fab.
12. *B. helferanus*, Seedl.

1. *Psithyrus rupestris*, Fab.
2. *P. distinctus*, Perez.
3. *P. barbutellus*, Kirby.
4. *P. campestris*, Panzer.
5. *P. quadricolor*, Lepeletier.

Of these, *B. agrorum* is the most abundant and widely distributed species, while *lapidarius*, *lucorum*, and *hortorum*, are almost equally common.

B. sylvarum and *helferanus* are fairly frequent; while *terrestris*, *pratorum* and *soröensis* are scarce. *B. jonellus* only occurred two or three times; while of *derhamellus*, three queens have been taken, and of *lapponicus* a single male only.

Of the *Psithyri* the most abundant is *campestris*, which preys upon *B. agrorum*: *P. barbutellus* is fairly frequent, as one would expect from the fact that it is parasitic on *B. hortorum*. *P. rupestris* is more frequent than *barbutellus*, while of *distinctus* two queens have been obtained, and of *quadricolor* one only.

The Honey Bee, *Apis mellifica*.

The Isle of Wight disease has caused serious loss around Aberystwyth during the course of the Survey. Commencing apparently near the

town, it rapidly spread and involved several flourishing apiaries, and has so far extended its ravages some $2\frac{1}{2}$ miles beyond the town. Thanks probably to their isolation, the country bee keepers so far remain unaffected, and it is greatly to be hoped that the disease has reached its limits. Apart from this scourge, local bee keepers have little to complain of and would do well. The usual bee pests, Wax Moth, *Braula caeca*, etc., are present but not in excess. The Blue Tit is responsible for taking a few bees.

Nematus ribesii Scop.

The Gooseberry Sawfly was fairly common in farm gardens in 1914, and was noted as high as 800 feet at Pont Erwyd. In a garden near Llanfarian the larvae appeared about April 25th and I noted a second brood there by June 20th, when, also, Red Currants were attacked adjoining the Gooseberries, although plenty of foliage still remained upon the former.

Finally, the following Mites may be mentioned.

Eriophyes ribis Nalepa. *E. avellanae* Amerl.

The first of these two bud mites occurs sporadically in gardens. *E. avellanae* is common in Hazels on hedgerows.

Tyroglyphus longior, the Hay Mite, was sent me from Pembrokeshire where it was destroying an Oat rick; and another correspondent sent specimens from feeding stuffs in N. Wales.

T. siro was found feeding upon the crystallised sugar on the top of a jar of jam, Aberystwyth.

A NOTE ON AGRICULTURAL OECOLOGY IN MID-WALES.

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During the progress of the Survey of Agricultural Zoology which I recently carried out in the Aberystwyth Area, some interesting and instructive inter-relations between wild and domesticated animals were noted.

The more natural conditions prevailing over large portions of Mid-Wales permit such interaction to be noted with greater readiness than would be the case in closely cultivated areas, where conditions are more controlled.

In the instances about to be given the main factors are:

(1) The distribution of the rabbit, which depends largely upon the physical conditions, and human control (which affects their relative abundance).

(2) The Sheep Industry, which is profoundly under the influence of the local custom of transhumance, involving the movement, twice yearly, of great numbers of sheep between upland and lowland.

(3) The abundance of foxes (a condition again somewhat influenced by the War).

(4) The number of sheep dogs kept; often excessive and insufficiently controlled.

In addition to the above are:

(5) The Poultry Industry.

(6) Hunting.

(7) The Sheep disease "Gid," due to the cysts of the parasitic Tape Worm *Taenia coenurus*, of which the hosts are the dog and the sheep.

(8) The distribution of the polecat, which is closely linked with that of the rabbit.

These two last are quite subsidiary and only included to show the complexity of the local animal inter-relation. My attention was drawn to these conditions through the complaints of farmers, shepherds, and poultry keepers, regarding serious losses of lambs and poultry, due to foxes.

The physical features of the area dealt with include the wide, open, grassy and peaty uplands of the mountain complex of which Plynlymon is the centre; the foot hills and river valleys often rough and wooded; the cultivated and fertile lowland and coastal region, and the large peaty tract bordering the Dyfi estuary and known as Borth Bog, or the Dyfi Flats.

On the mountains the sheep receive relatively little attention, and the amount of necessity depends very largely upon the size and nature of the holding or "walk," the number of sheep, and the persons responsible for their care. Even if more or less tended by day, the sheep are exposed to any danger that may threaten them during the night and early morning. The condition of affairs here described may possibly apply, with some modification, to other mountain areas.

During the progress of the survey I received 70 complaints of damage to lambs and poultry by foxes, and it would have been easy to add largely to that number if farm visiting had been continued on the same scale in 1916 as in the previous years. The complaints, as indicated above, fall under two heads:

(*a*) lambs, (*b*) poultry, and these must be considered separately.

Foxes are common in the area, and are hunted by the pack of hounds kept by Sir Edward Pryse, Bart., at Gogerddan, near Aberystwyth, about the centre of the area. This pack has not, of course, hunted to the same extent since the outbreak of War, and foxes seem to have increased both in numbers and boldness.

A second pack has quite recently been started on the southern side of the area. Cubs were reared, and poultry raided even in the town of Aberystwyth, and many foxes were perforce destroyed by farmers and others throughout the area in sheer self-protection. The chief losses of poultry are, of course, practically confined to the lowlands and valleys, few poultry being kept at higher elevations, and in addition to the direct loss there must be added the discouragement of poultry keepers. Part of the loss is due to bad management, and careless housing of fowls due to slackness on the part of the poultry keepers, and partly owing to lack of suitable places in which to house them. The loss of lambs occurs chiefly in the mountains, and in certain districts is serious.

That much of the loss is due to foxes is certain, but I do not consider that the whole of the damage attributed to them can be laid to their account.

Dogs are responsible for a considerable share, and often I believe the dogs of the farmers themselves, though many are unwilling to admit it. Dogs are left loose in some instances with a view to protection from foxes. It is my opinion that too many dogs are kept on many of the farms and sheep walks, and very frequently these are not sufficiently well fed. Quite a number of outbreaks of lamb killing have been traced to dogs (and some of these were destroyed) during the progress of the Survey, but it is unlikely that I have heard of more than a part of the total.

Again, these dogs, and others, are very seldom kept shut up at night, and a considerable proportion roam the hills at will. When stopping here and there in the hills during the course of the Survey I have been disturbed during the nights by such prowling dogs. It would no doubt be difficult to track many, but the practice is very harmful in this and other connections. Nevertheless, although some part of the total loss is attributable to dogs, the fact remains, that a heavy and unnecessary toll is taken by foxes at the expense of sheep farmers. Complaints of loss vary from four or five lost to 40 or 45, and in the spring of 1913, one group of eight sheep walks together claim to have lost 300 lambs. The most dangerous period in the hills is usually May, when thousands of ewes and lambs are taken from the lowlands to the mountain walks for summer grazing. A proportion of ewes are lambed on the sheep walks, in some cases depending largely on the elevation and the amount of improved land available.

If a map is constructed showing the distribution of these troubles it will be noted that a very considerable proportion of the complaints of loss come from the hill country lying W. of Plynlymon, and more or less in the centre of the Survey Area, and further that it comprises the hinterland of the region most hunted. Another point of great importance shown by mapping is the distribution of rabbits within the area. It will be observed that very few rabbits occur in this region showing the greatest damage to lambs, in marked contrast to the state of affairs in the southern part of the area. There is no doubt that foxes everywhere depend very largely upon rabbits for their food, and in these hills rabbits are either very locally distributed or quite absent. Moreover it so happens that the maximum number of lambs are available just when the vixens have to feed their cubs and teach them to hunt;

and finally, it is contended by some that hunting in the lower lands drives lowland vixens into the hills and so further accentuates the coincidence of circumstances which cause trouble. I have myself examined lambs found dead, and partially eaten, upon the sheep walks in that region, and consider their deaths were due to fox attack.

A minor annoyance due to foxes is the manner in which they tear and mutilate rabbits caught in traps and snares. Foxes are made aware of the whereabouts of such rabbits by their cries when first caught. A curious custom, the origin of which is obscure to me, is that of putting raddle or red paint upon the back of lambs, to keep off foxes. Another local idea is that foxes show a preference for white fowls: and this may be explained perhaps by the greater prominence of such birds at night, etc.

One farmer says that he has observed foxes catching moles, digging them out as dogs sometimes do.

Rabbits are particularly abundant along the coast region between Aberystwyth and Borth, and also in the valley of the Ystwyth; but comparatively few complaints as to damage have been made to me. This is possibly due to the amount of rough land and the wide range they usually enjoy, for very seldom does a colony occupy narrow limits surrounded by cultivated land. In certain cases, however, I have seen considerable damage to young corn, and also to meadow grass. Throughout the remainder of the lowlands and slope lands rabbits are usually present in small numbers, but on the mountain tops they are very scarce, or entirely absent, especially on peat. There are several interesting exceptions; in one instance at an altitude of 1300 feet, a colony is established in a fir plantation, three miles from any other colony of which I am aware.

The other exceptions are due to the physical characters of the Drosgol Grits, which weather into rough screes formed of blocks of stone that provide shelter for rabbits from whence it would be extremely difficult to dislodge them. I am aware of three such isolated colonies, two at 800—1000 feet, and the other at 1200—1600 feet. From what I can gather, certain changes have taken place in the local distribution of recent years; in two districts a reduction in numbers is apparently due to persistent trapping, etc., but in another to a severe outbreak of Coccidiosis (*Eimeria stiedae*), which disease I have several times observed. I have not been able to obtain any rabbits suffering from Liver Rot, but several farmers informed me that during recent outbreaks they observed flukes in the livers of rabbits

killed on their farms. A liver containing a very considerable number of flukes was sent me from Mid-Pembrokeshire in 1913.

The distribution of the Polecat (*Mustela putorius*), which is by no means uncommon in North Cardiganshire, seems to be largely governed by that of the rabbit, upon which it largely preys. The polecat is now and again responsible for some loss to poultry keepers. I conclude therefore that foxes are over abundant in the area, and, as elsewhere, are a needless source of loss to sheep farmers and poultry keepers. In rough country it is always difficult for the hunt, however well intentioned, to kill all troublesome foxes, and the more their numbers increase the greater becomes the difficulty of the chase. The present over abundance will doubtless, to some extent, be dealt with by the sufferers. As regards the dog problem, although sheep farmers claim that large numbers are needful in order to work their widely-ranging flocks, I nevertheless consider that a diminution in their number, coupled with a greater control and better feeding and attention in some cases, would result in a reduction of trouble, and also in the number of young sheep suffering from "Gid." There will probably always remain enough foxes to provide sport for the hunting people.

Rabbits again could with advantage be reduced in numbers in certain districts, and land given up to them utilized to better purposes. On the whole they can usually be readily controlled within the area under consideration.

A general account of the Mammals of North Cardiganshire will be found in a paper by Mr F. S. Wright, in the *Zoologist* for September, 1916.

ON A DISEASE OF THE BEECH CAUSED BY *BULGARIA POLYMORPHA* WETT.

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(With Plate I.)

During the last few years, a number of the pollard beech trees at Burnham Beeches have suffered from a disease which has apparently caused the death of several specimens, and is seriously affecting some others. The symptoms of the disease are very marked. At various points on the surface of the bark a brown liquid exudes which rapidly concentrates to a dark viscous gum[1], collecting in gouts near the point of exit and, if in quantity, trickling down to lower levels. The material is partially soluble in water, with the result that in wet weather it is washed down and may be thus distributed over a considerable area of the lower part of the trunk. The effect is very unsightly and the trees attacked are readily detected (Fig. 1). Frequently the gum provides a medium for the growth of various saprophytes, yeast, bacteria, moulds, etc., and then becomes of a creamy consistency and buff or pinkish in colour.

The effect on the tree is very serious. The bark from which the gum proceeds is already dead, and since the affected areas are often rapidly extended, the life of the tree may be seriously threatened.

These pollards are probably some of the oldest beeches in existence. Their life has been prolonged far beyond what is generally regarded as the normal limit of the species by the systematic pollarding, which—as was usual in ancient forestry—was done at such a height as to protect the young shoots from browsing animals. The cessation of cutting, however, permitted the growth of a few of the more favoured shoots and the trees now bear several fine limbs rising from the crown.

[1] This substance has been referred to throughout as gum, though its exact nature has not yet been determined.

It is obvious that pollards are particularly exposed to the attack of parasites which can obtain an entrance and destroy the heart wood, and these old beeches are in most cases nothing but hollow shells. The outer wall of wood and bark has also suffered frequently from accidental injury and disease, and is now a patchwork of dead and living tissue. In fact it is astonishing to observe in some instances, how restricted is the tract of living, conducting tissue, which connects a well-developed limb above with the root system below. It must operate as a limiting factor in the relations between the root system and the leafy canopy dependent upon it above; and it is a fact that the trees are extremely sensitive to anything which tends to disturb these relations, *e.g.*, dry seasons, clearing and felling in the immediate neighbourhood. For the same reason they demand constant attention in the matter of pruning, mulching, etc. It is obvious that any attack on these vital tracts must rapidly prove fatal, and they are particularly exposed to the ravages of facultative parasites which have established themselves on the neighbouring areas of dead tissues. Moreover diseases affecting the bark are much more rapidly fatal than those attacking the wood, since the death of the inner bark and with it the cambium, deprives the tree not only of the means for conveying its elaborated food materials, but of its capacity for forming new tissues. A number of fungi are found constantly growing on the pollards, and amongst others *Fomes fomentarius*, *Stereum hirsutum*, *S. purpureum*, *Armillaria mucida*, etc.

The Ranger, Mr M. C. Duchesne, observed that fruit bodies of *Bulgaria polymorpha*, Wett., were often abundant on trees exhibiting the gumming. The evidence of association however between the fungus and the disease was not at all convincing.

At the time our attention was first called to the disease the fruit bodies of the fungus were scarce. Trees showing the gumming often exhibited no trace of *Bulgaria*, whilst on the other hand felled logs, with the bark covered with the scars and remains of old fruit bodies, usually showed no evidence of gumming. It was possible moreover that the disease might have no connection with a parasite, but have resulted from some functional disturbance. Our attention was therefore directed not only towards the examination of the diseased bark for evidence of the presence of any living organisms which might be concerned with the disease, but also to determining whether the disease could be transmitted to healthy trees.

Association of Bulgaria with the Disease.

A number of specimens consisting of portions of wood and bark from diseased trees were forwarded for examination. They all showed a covering of gum on the surface of the bark which in most cases was dead. Examination of the bark yielded no results of any value. In one specimen only, a yellow mycelium was found between the bark and the wood. This was probably the mycelium of *Bulgaria*, but attempts to cultivate it failed. Subsequent examination of the trees from which the specimens were cut, suggested that in some instances the gum on them had trickled down from a diseased area higher up the trunk. Two specimens were placed in a damp chamber and kept under observation for about 18 months. No exudation of gum occurred from these specimens. A few saprophytic moulds appeared at first on the gum and later *Stereum hirsutum* in abundance on both specimens. In the spring of 1916 the examination of the infected trees was resumed and was confined to the careful investigation of one badly diseased tree in Victoria Avenue, Burnham Beeches. One of the two main branches of this tree had died and had been removed in the winter of 1914–15. The log showed abundance of *Bulgaria* fructifications during 1915. The remaining branch of this tree is still living and apparently healthy, but a considerable area of the bark at the base is dead and although no gumming has taken place in this region, yet infection experiments (described below) show that the same disease is in question. It was from the base of the main trunk that the specimen, referred to above as showing yellow mycelium, had been obtained. Fresh portions of bark from this region, which was gumming freely, were brought into the laboratory and on one of them a yellow mycelium appeared. This was transferred to an artificial medium and has been kept in continuous cultivation. Of the various media tried, prune agar proved to be the most satisfactory. Four weeks after the material had been collected a fructification of *Bulgaria* appeared on the bark and could be clearly traced in connection with the yellow mycelium.

Ascospores were collected on sterile cover glasses suspended over the apothecium, and were transferred to various media. They germinated readily and gave rise to a mycelium identical with that obtained from the diseased bark. Other specimens of bark brought in later also developed fruit bodies of the fungus, and portions of bark taken from other diseased trees in every case yielded the yellow hyphae. Pure cultures of the mycelium have been under observation for many

months both on nutrient jelly and on sterilised bark and wood. The characteristic apothecia of *Bulgaria* have appeared in a number of the cultures, and thus complete confirmation has been obtained as to the identity of the mycelium present in the diseased bark.

Infection Experiments.

The first infection experiments were started in the autumn of 1915, before the mycelium had been found in the bark, and were directed towards determining whether the disease could be transmitted from affected to healthy trees. For this purpose, portions of bark were removed from the affected area at the base of the living branch of the pollard in Victoria Avenue. The bark was cut out, with suitable precautions, with a circular punch and transferred to holes cut with the same punch in the living bark of a healthy pollard. They were secured with grafting wax. Of the grafts made in this way, one shrivelled and cracked and fell out, and another gave no visible result, but the third examined on May 7th, 1916, showed a trickle of gum from the lower edge of the graft forcing its way through the grafting wax (Fig. 2). This exudation continued during the whole of the year. Examination of the bark around the graft showed that the gum was proceeding from the stock, and thus established the fact that the disease was communicable and certainly of parasitic nature. The difference in the behaviour of these three grafts is very probably due to the fact, that the two which failed were cut from well within the dead region of the bark, the other from the margin of the diseased area where the fungus was presumably in active growth. It may be pointed out moreover, that the absence of gumming from these unsuccessful infections resolves any doubts as to the exudation of gum being merely a traumatic response.

When later, the yellow mycelium described above had been isolated and identified, a second series of infection experiments were initiated. The same pollard on which the first experiments were made was now infected in two places on July 11th with actively growing mycelium, in one case from that obtained by germinating spores of *Bulgaria*.

The surface of the bark was cleaned and a deep cut, extending to the cambium, made with a sterilised chisel. The bark was gently levered up and a portion of agar, with the actively growing marginal hyphae from a plate culture, was inserted and pushed down into contact with the wood. The bark was then pressed back into position and the wound covered with grafting wax. At the same time two young trees

were similarly infected. Three weeks later, July 31st, one of the infections on the pollard showed signs of gumming, and by the end of August they were both gumming freely (Fig. 3). Mycelium of *Bulgaria* has been isolated from the bark, though up to the present no ascophores have appeared on the tree.

On the other hand, the infections on the young trees have yielded no visible result. These same young trees were again infected with active mycelium on Sept. 27th, but without success, and they are now apparently quite free from disease.

The power of resistance to the attack of the fungus possessed by the young bark on the living trees is further exemplified by the results of experiments in the laboratory. On July 20th a series of cultures in potato dishes were established on portions of wood and bark about $4'' \times 3''$ taken from a young healthy branch, severed for the purpose. One half of these specimens were sterilised in the autoclave before infecting, the remainder were infected straight away with actively growing mycelium at the junction of bark and wood. The infections were uniformly successful on those specimens which had been killed and sterilised, but failed to establish themselves on the living bark, although in several instances a second infection was attempted. The results of these experiments were so significant that they were repeated on Oct. 6th. Five specimens of living bark and wood $4'' \times 3''$ being infected with mycelium together with five similar specimens killed in the autoclave. Four days later the fungus was spreading rapidly on the dead bark but had apparently made no progress on the living specimens, the latter were then reinfected, but without result.

In no instance was it possible to establish *Bulgaria* on the untreated bark, although in one or two cases it maintained itself for a short time on the dead tissue at the point of infection. It is obvious that the living tissues of these specimens cannot long retain their vitality, and it would no doubt be possible to get *Bulgaria* to grow successfully after a short time, if it were not for various saprophytic moulds, and particularly a dense white mycelium, possibly of one of the Polyporaceae, which appeared on all the specimens and against which *Bulgaria* could make no headway. The results obtained from the foregoing experiments and those on the living trees indicate that whilst the fungus can establish itself readily on dead bark and on the bark of old trees, it fails completely when the bark is young and actively living.

When the fact is borne in mind that infections on young, healthy trees failed completely, though made with actively growing mycelium

of the fungus, it may be concluded that there is little danger of the fungus establishing itself by chance infection of spores on young, vigorous maiden trees. The success of the inoculations on the pollard can probably be ascribed to the impaired vitality of these trees, and the consequent lowering of the power of the living tissues to resist attack. The fungus established on a dead area of bark can thus invade the neighbouring living tissues, it develops rapidly in the inner bark and attacks the cambium and the superficial layers of the wood. It may be as well to emphasise the fact that on these beeches at any rate *Bulgaria* does very little injury to the wood, but is responsible for the death and destruction of the bark.

Dissemination of the Disease.

The familiar black apothecia of the fungus appear in early autumn (Fig. 5). They eject their spores in such abundance that the surrounding bark is covered by a black sooty deposit. The investigations of Tulasne(1) and Brefeld(2) have shown that the spores germinate readily, giving rise to secondary conidia or to mycelia directly according to the conditions of germination. The ascospores thus serve as a ready means for the dissemination of the fungus but by no means the only one. If they establish the mycelium on an exposed wound it is able in the enfeebled trees to extend itself to the living tissues. The principal development of the fungus takes place in the spring and early summer, as is evidenced by the active gumming that goes on at that time. When the bark has been completely permeated by the fungus the latter collects between the outer bark and the thin covering layer of cork, and forms shallow stromata on which are later formed the apothecia. Before these appear however, other fructifications are developed on the stroma in the form of numerous pycnidia. These are borne in irregular fructifications which form close beneath the lenticels and usually split the cork at those points. These prominences show in surface view the numerous irregular openings of the pycnidia, from which emerge rounded masses, or fine tendrils of black paste, which make their appearance on the surface of the bark, hardening on exposure to the air but readily dispersing when moistened with water (Figs. 4 and 5).

This paste consists entirely of the pycnoconidia (stylospores) described by Tulasne(1). They bear, both in size and form, a strong resemblance to the ascospores and behave in a precisely similar way on germination. In all the material examined at the right season these

pycnidial fructifications were abundant. Their regular occurrence and relative importance appear to have been generally overlooked by later writers although Tulasne refers to them as occurring not infrequently. Fuckel(3) described them and identified them erroneously with *Tremella foliacea*, Pers. (*Ulocolla*, Brefeld), with which they have no connection. Fuckel had apparently never found them in conjunction with the apothecia and says "Die Combination beider mag immerhin als gewagt erscheinen; die entfernte Aehnlichkeit aber der Conidien mit den Schlauchsporen und die Analogie mit *Coryne*-Arten, verliehen derselben doch grosse Wahrscheinlichkeit."

The pycnoconidia are produced during the summer months, the apothecia in the early autumn and they can frequently be found together on the same stroma (Fig. 5). Biffen(6) observed the formation of the pycnidia in his cultures of *Bulgaria* on oak wood and they have appeared in all our cultures both on the bark and on plum agar.

Other Records of Parasitism of Bulgaria.

The suggestion that *Bulgaria* should be classed as a facultative parasite was first put forward by Ludwig(4) who described in 1887 a fatal attack on a fine specimen of *Quercus rubra*. A similar instance is recorded by Hennings(5) on the same species of *Quercus*, and this author is inclined to regard the fungus as a dangerous parasite.

Biffen(6), who studied the effect of the hyphae on oak wood, found that the action was too slight to warrant the supposition that the fungus is capable of causing a really serious tree-disease such as Ludwig(4) assumed. A reference to the latter's account however, shows that he attributes the death of the oak to the destruction of the bark by *Bulgaria*, and not to its effect on the wood. The results of the present investigation clearly indicate that in the beech also, the fungus is primarily a bark-parasite.

So far as the authors are aware, no account has hitherto been published of an attack on the beech, apart from a statement by Massee(7) that he has seen it on living beech, and no infection experiments have been recorded. It is noteworthy that at Burnham Beeches the pollard oaks have so far been quite free from attack.

The investigation has been confined to the pollard trees at Burnham Beeches, but the Ranger, who has examined beech plantations in various parts of the country, has found the disease on mature maiden trees in several areas in Buckinghamshire, at Tring in Hertfordshire, Walton-on-Hill in Surrey, and in the Goring district of Oxfordshire. It is

Fig. 1. Diseased pollard beech showing gumming.

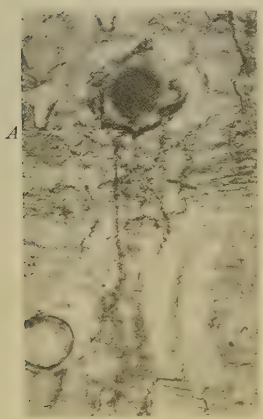

Fig. 2. Graft made in September 1915. Photographed in July 1916 to show the gum exuding from the lower edge of the graft at *A*. $\times\frac{1}{5}$.

Fig. 3. Bark of pollard infected with living mycelium, July 1916. Photographed eight weeks later when actively gumming. $\times\frac{1}{5}$.

Fig. 4. Masses of pycnospores exuded through cracks in the bark from the pycnidia on the stroma beneath. $\times\frac{3}{4}$.

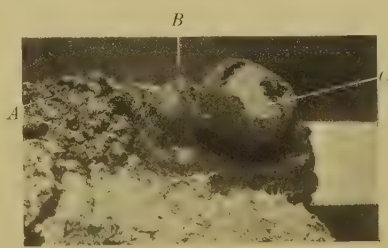

Fig. 5. Stroma exposed by the removal of the superficial cork showing masses of pycnospores at *A*, young apothecium *B*, and mature apothecium with hymenium exposed *C*. $\times\frac{1}{4}$.

obvious therefore, that the peculiar circumstance of the pollard trees is not alone responsible for their susceptibility, and it must be concluded that *Bulgaria* may prove a dangerous parasite to old beeches, more especially when from various causes their vitality may become impaired.

Up to the present the actual source and nature of the "gum" has not been determined. Preventive and remedial measures are under consideration.

Summary.

A gumming disease of pollard beeches is described which is associated with the presence of *Bulgaria polymorpha*, Wett. on the trees.

A mycelium isolated from the diseased bark has been cultivated and has produced the fructifications of *Bulgaria*.

A pollard has been infected with the disease by grafting in a piece of diseased bark, and also by introducing the mycelium of *Bulgaria*.

Repeated infections of young, vigorous trees with the mycelium failed to produce the disease.

It is concluded that *Bulgaria* is a dangerous facultative parasite on old beeches, but that young healthy trees are able to resist infection.

We take this opportunity to record our thanks to M. C. Duchesne, Esq., the Ranger of Burnham Beeches, for the facilities he has readily afforded us and for the information he has placed at our disposal.

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THE LIFE HISTORY AND ECONOMY OF THE CHEESE MITES.

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The work on Cheese Mites, of which this paper gives a preliminary report, was undertaken in the Zoology Department of University College, Reading, at the suggestion of Dr R. Stenhouse Williams, of the Dairy Research Institute, and in collaboration with Mr A. Todd, Manager of the British Dairy Institute, University College, Reading.

The losses due to the depredations of cheese mites are very severe. According to statistics obtained by Dr Williams, about 100,000 Stiltons (the cheeses most affected) are made annually in this country. These cheeses weigh on the average when ripe about 14 lbs., and before the war sold at the rate of 1*s.* per lb. Estimating the average loss due to cheese mites at $2\frac{1}{2}$ % of the whole cheese (a not very excessive estimate) and the labour involved in attending to the cheeses at 4*d.* per week for each 100 cheeses for a period of 26 weeks, we obtain the following figures:

Value of 100,000 cheeses each weighing 14 lbs. at 1*s.* per lb.	£70,000
Loss due to cheese mites $2\frac{1}{2}$ %	£1,750
Labour 4*d.* per week for each 100 cheeses for 26 weeks (approx.)	£433
Total loss	£2,183

With a view to minimising and if possible preventing this loss the following work was done, aided by a research grant from the Board of Agriculture and Fisheries.

Systematic Position.

The nearest relatives of the Mites are the Spiders and Ticks. In these forms the body is incompletely divided into two, the fused head and thorax and the abdomen. There are four pairs of legs in the adult and two pairs of mouth parts, which are adapted for biting, piercing or sucking.

Many mites are parasitic, for example, the Itch mites. Others, like the cheese mites, feed on food substances, while a few are carnivorous and beneficial. As a group the Mites are much simpler in organisation than the spiders and though not very numerous in species, they cause an immense amount of damage, owing to their short life cycle, their rapid propagation, their powers of resistance and their means of distribution.

SPECIES.

Four species attack cheese. All of these are to be found on old Cheddars and three species on Stiltons and Wensleydales. It must be remembered, however, that although unpressed, ungreased cheeses suffer most damage, old cheeses of any kind are liable to attack. Further, these so-called cheese mites do not confine their depredations to cheese, but will thrive equally well on flour, stored grain, dried fruits and drugs, hay, etc., provided these are allowed to get damp. The four species of Cheese Mite, which all belong to the same family of Mites, are:

(1)	*Carpoglyphus anonymus*[1]	The Cheddar Mite.
(2)	*Tyroglyphus siro*	Stilton and Cheddar Mites.
(3)	*Tyroglyphus longior*	,, ,, ,,
(4)	*Aleurobius farinae*	,, ,, ,,

Carpoglyphus is readily distinguished from the other three species by its greater opacity. It is of a deep cream colour when found on cheese. *Tyroglyphus siro* is a somewhat sluggish species with heavy body, short legs and long hairs. *Tyroglyphus longior* closely resembles *Tyroglyphus siro*, but it is less heavily built and is exceedingly active. Its hairs are very long and its legs pinkish. *Aleurobius farinae*, the Flour Mite, has deep reddish brown legs and short hairs. The first pair of legs in the male are very stout and spurred at the base.

LIFE HISTORY.

The life history, which is similar in all the species, consists of four stages, the egg, larva, nymph and adult male or female. From egg to adult stage occupies about four or five weeks. In working out the life history the method suggested by Michael was used[2]. Glass cells

[1] The name *Carpoglyphus* means the fruit-cutter, because this species frequently attacks dried fruits. *Tyroglyphus* means cheese-cutter, *Aleurobius farinae* the living organism found in flour.

[2] *British Tyroglyphidae*, I. p. 135.

were made by fixing a glass ring about one-eighth of an inch in height to a slide. The adult male and female were then placed in the cell along with a small piece of cheese, the base of the cell having been previously covered with a piece of blotting paper, which was kept moist. The upper rim of the glass circle was smeared with vaseline and a small strip of glass placed on the top as a lid to prevent the mites escaping. The cells were examined every day under the microscope and records of the duration of the various stages were kept. When about three eggs had been laid the male and female were removed but the eggs left. The exact date when the egg was laid was therefore known and the young stages became used to living in the cell. It was much more difficult to keep the mites alive, if the cells were started with the larva or the nymph stage.

The eggs are white oval bodies, so small as to be only just visible to the naked eye. They hatch in about 10—12 days after being laid. On hatching, the young mite is known as a *larva*. It is colourless and of a glassy appearance, and has three pairs of legs only. The larva feeds actively for about a week, then becomes quiescent and casts its skin, emerging as the *first nymph*. The first nymph has four pairs of legs and is somewhat larger than the larva. It moults again and becomes the *second nymph*, larger and more highly chitinised than the first nymph. After its third moult, the mite emerges as an adult male or female, the sexual organs not being functional until the final stage is reached.

In *Tyroglyphus longior*, however, there is an additional stage after the first nymph stage, which is specially adapted for distributing the species. This stage is known as the Hypopus stage and occurs under favourable conditions, that is, when the mites are allowed to breed unchecked. The Hypopus is like a minute tortoise. It is extremely small, pinkish in colour, and has a hard, shelly back of chitin. The legs are short, the mouth parts rudimentary, and there is no evidence that it feeds. On its ventral side it has a sucker plate by means of which it attaches itself to other mites, to flies and moths which alight on the cheeses, or even to the skin and clothes of human beings. It is thus carried about until it finds a suitable place, when it drops off, moults to become a second nymph, and commences feeding.

Practical Considerations.

The following questions present themselves for solution.

(1) How do new dairies become infected with mites?

(2) How do new cheeses become infected in a cheese room previously attacked?

The second question may be more conveniently dealt with first and its solution involves to a large extent the answer to the first question. Stiltons are usually made from April to September, and are then cleared out of the dairies by December. From December till the end of April, that is to say, till the next Stilton season, the Stilton room is usually empty or is used for other cheeses which are not attacked by mites unless very old. From such a cheese room, which had been used since Christmas only for cheeses that are not usually attacked, scrapings from corners, window ledges and shelves were taken in June. In each case, amongst a mass of dust and dead bodies of mites, a few live mites were found. The new Stiltons were placed on the shelves at the end of June and in a fortnight's time showed numbers of mites on the coat. The mites that attacked the new Stiltons, therefore, were already present in the cheese room. The ordinary cleansing methods had failed to kill them, yet the greatest care is taken in this dairy to keep the place thoroughly clean. Eggs were never seen in the scrapings; all the individuals were adults, and it appears probable that the interval between the Stilton periods is tided over by adults. Now if these few adults are the source of mite attack on the new Stiltons, how do they spread from cheese to cheese and from shelf to shelf? It is obvious that on emerging from their retreats they will crawl to the nearest cheeses, but this does not entirely explain how they pass from one shelf to another. Two experiments were carried out in order to ascertain this. In both these experiments the crawling of the mites to the cheese was prevented by a band of grease in the one case and by a water bath in the other.

Experiment 1. A trestle stool, which had never been used in the cheese room, was thoroughly scrubbed and placed in the centre of the Stilton room. The legs were thickly smeared with vaseline about six inches from the floor. Any mites, therefore, that attempted to crawl up from the floor would be caught by the grease band. A sheet of plate glass was placed on the trestle and on it four new Stiltons. These cheeses were turned each day by the same student, who did not touch any of the mite attacked cheeses, so that it was improbable that she could carry mites to these four cheeses. Since the mites could not crawl on to the cheeses, and these were nevertheless attacked about two weeks later than the other Stiltons in the room, there were three possibilities;

(1) That the mites could be carried by flies, which were observed crawling over the cheeses.

(2) That the mites, being so small, could be blown by a draught across the small space between shelves and trestle.

(3) That the person who turned the cheeses, in spite of the care taken, may have carried the mites.

A fly paper was hung up in the room and the flies caught on it were examined under the microscope. Mites in small numbers were found attached to their legs, so that there seems to be no doubt that mites can be carried in this way. In fact, the Hypopus stage (see life history above) is specially adapted for conveyance by this means. If the mites can be carried short distances by flies, there is every possibility that new cheese rooms become infested by mites carried by flies, moths and other insects which have previously visited places where these small creatures abound.

Experiment 2. The trestle in this case was not grease banded, but on it was placed a large bath containing water to a depth of about two inches. It had been previously ascertained that mites could not traverse a piece of water, so that any mites that crawled up the legs of the trestle and over the edge of the bath would fail to reach the cheeses, which were placed on boards elevated above the water. These cheeses were attacked by mites at about the same time as those in Experiment 1, that is to say, about two weeks later than those that were put on the shelves, and presumably from the same causes, for moths and flies were seen on these cheeses also.

Of the three possibilities mentioned above, therefore, the first becomes a fact, viz., that flies and moths can carry the mites. No experiment has yet been made to show whether the mites can be blown through the air, though it is highly probable that this is the case, at any rate for short distances. The possibility of the person who turned the cheeses conveying mites must not be overlooked, though every care was taken to prevent it. Anyone who has turned mite-eaten cheeses, however, will realise that human beings can carry mites from one place to another, and will have experienced the tingling and itching sensation due to the presence of the mites on the skin. Although mites have no eyes[1], they can distinguish between light and darkness, and of the two they prefer darkness. If the breeding cells mentioned above were kept in the light, the mites hid under the blotting paper

[1] *Carpoglyphus* has "eye-like organs," but these have no pigment and it is doubtful if this mite can see.

and it was often very difficult to find them. By keeping the cells in the dark, however, the mites appeared to thrive better and were more easily found when the cells were examined from day to day. It follows from this that mite attack is worse in a dark cheese room than in a light one, and the practice of having cheese rooms partly or entirely under-ground is favourable to the mites, although necessary in order to maintain an even temperature.

Their fondness for darkness, however, is excelled by their love of cracks, crevices and corners. They creep into cracks in the cheese boards and shelves, and soap and boiling water will *not* kill them. It is, in fact, extremely difficult to kill the adult mite and almost impossible to kill the egg. These mites have no breathing organs, but breathe through the thin cuticle, so that it is far more difficult to kill them by suffocation or fumigation than it would be if they possessed breathing tubes like those of insects. The methods employed in the dairies for keeping them in check are therefore often only waste of good material. Some cheese makers, for example, dip the cheese in formalin, believing that the formalin will kill the mites. Mites have been kept immersed in 5 % formalin *for over a week* and at the end of that time, though some had died, many were still active! The formalin washes off the surface mites, but kills none of them. A very large number of substances were experimented with, but only two were found which killed the mites within a short time. These were Carbolic acid and Carbon bi-sulphide. Carbolic acid, being poisonous, cannot be used on the cheeses themselves, but it might be used for scrubbing the shelves, and especially the corners. A 5 % solution killed the mites in two minutes; increasing the strength did not cause their death any sooner than this. Four 10 lb. Stiltons were removed to an unused room, freed from mites and kept free by the use of Carbon bi-sulphide. This substance is a heavy, yellow and evil-smelling liquid which vaporises very readily and which leaves behind neither smell nor taste. It is used on flour, grain and many other food stuffs and destroys all forms of animal life. It is not harmful when breathed in small quantities by human beings, but is highly inflammable and should not be brought near a light. The vapour of the bi-sulphide kills the mites almost instantaneously, but although it is a heavy gas, the vapour does not work underneath the cheeses, neither does it kill the eggs. The bi-sulphide was used in several ways until the most satisfactory was found. (1) The cheese was covered with a bell jar and a shallow vessel containing the bi-sulphide was stood on an inverted gas jar placed inside

the bell jar. The bi-sulphide was then left to evaporate. The reason for elevating the fumigant is that the vapour is heavy and therefore sinks. The majority of the mites were killed, but some still survived at the base of the cheese. (2) The cheese was sprayed with the bi-sulphide by means of an ordinary garden spray. It was then inverted and the base treated. This method is, however, wasteful. (3) The cheese was painted all over the surface with the bi-sulphide by means of a large paint brush. This method was found to be the most effective, though it would be difficult of application on a large scale and the cost might be prohibitive[1].

It was necessary to treat the cheeses three times, once to kill the adults, a second, at an interval long enough to allow for the hatching of the eggs, to kill the larvae, and a third after a similar interval to make sure that all were killed. Thus the four cheeses received their first treatment on September 11th, 1916, the second twelve days later, and the third after the same interval. No mites were afterwards observed, the cheeses ripened satisfactorily and were kept free from mites from October, 1916, to February, 1917, when they were returned to the dairy and sold.

Further experiments with Carbon bi-sulphide will be carried out on a larger scale during the present year. I do not think, however, that it would be easy to free large numbers of Stiltons from mites by any fumigant when once they have been attacked. The mites are so small and breed so rapidly that it is extremely difficult to exterminate them. The hope seems to lie rather in preventive methods, that is, in a thorough cleansing of the dairy in the interval between the clearing out of the ripe Stiltons and the making of the new ones, and an attempt to do this will be made in the cheese room at University College, Reading.

The following recommendations arise naturally from what has been said above:

(1) All the windows should be netted to prevent the entrance of flies and moths, which carry mites. If doors are left open, they should have a netted inner door for the same purpose. This precaution would also eliminate "skippers" from the cheeses, by preventing the ingress of cheese flies.

[1] The price of Carbon bi-sulphide is at present 11*d.* per lb. About 5—8 ozs. were used for the four cheeses in question at each fumigation and there were three such fumigations, so that the total cost was about 1*s.* 6*d.* for the four cheeses. The cheeses were subsequently turned but not brushed as there was no dust on them. The cost of brushing was therefore saved.

(2) There should be a very thorough cleansing of the dairy between one Stilton season and the next in order to kill those mites that persist and are waiting to attack the next set of Stiltons. Corners, window ledges and crevices of any kind are their favourite hiding places, and the whole of the ceiling, walls, floors, shelves and their supports should be thoroughly cleansed, and all woodwork treated with 5 % Carbolic solution. If the walls are not tiled or made of glazed brick, they should be lime-washed every year. Limewash does not kill mites, but the movements of the brush would dislodge them or perhaps crush them.

(3) It is advisable to have movable shelves of short lengths. Ideally the shelves would be made of glass, as then only could one be sure that there were no mites on them. The supports are better made of iron than of wood, because, with scrubbing, the cracks in the wood increase in number and depth and so harbour the mites. For the same reason, floors should be made of concrete, with gutters for drainage. If the Stilton room is not in use between the Stilton seasons, the shelves should be removed, treated with Carbolic and then kept in daylight and allowed to dry.

(4) When Stiltons are attacked by mites, the damage is lessened very considerably by brushing the cheeses daily and removing the mite dust.

INVESTIGATION OF BULB ROT OF NARCISSUS[1].

PART I. THE NATURE OF THE DISEASE.

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(With Five Text-figures.)

Introduction.

The date of the first appearance of the disease in this country is somewhat doubtful. Mr J. W. Barr, of Messrs Barr and Sons, states that he first observed it about twelve years ago in some bulbs of *Narcissus Horsfieldii* imported from Holland.

Massee(9) found *Fusarium bulbigenum* (Cooke and Massee) in Narcissus plants suffering from bulb rot and ascribed the disease to this cause. As, however, no infection experiments were carried out, and as there seems some evidence that *Fusarium bulbigenum* may exist in healthy bulbs, it is clear that the nature of the disease was not settled by Massee's observations. The absence of definite knowledge as to its cause and the increasing ravages of the disease obviously made an investigation very desirable.

Diseased bulbs were obtained in April, 1915, and a preliminary examination showed them to be infested with various animal pests, chief among which were *Rhizoglyphus echinopus*, *Eumerus strigatus*, *Merodon equestris*, and *Tylenchus devastatrix*: certain scales were also found to contain *Fusarium bulbigenum* and bacteria. It was necessary, therefore, to determine which, if any, of the above was the primary cause of the bulb rot.

[1] This investigation was undertaken jointly by the Imperial College of Science and Technology and the Royal Horticultural Society.

Infection Experiments.

A series of experiments was begun in September, 1915, on bulbs grown in cold frames at the Imperial College of Science and Technology, and in prepared beds at Chelsea Physic Gardens. It was found, however, that more trustworthy results would be obtained if the bulbs could be grown under better conditions, such as those obtaining in the larger nurseries. For this purpose, Messrs Barr and Sons were good enough to provide facilities, and since March, 1916, experiments and observations have been carried out in their fields and drying sheds at Taplow.

Infection with Bacteria.

Infection experiments were carried out with seven strains of bacteria which had been isolated from diseased bulbs and grown on either Narcissus or potato-mush agar. Healthy bulbs were planted in September, 1915, and were infected with pure cultures of the several strains in the following month. A piece of the bulb was cut out with a sharp sterilised scalpel and a portion of agar with the bacteria was placed at the bottom of the pit, after which the piece of bulb was replaced. Healthy cut and uncut bulbs were planted as controls. When the plants were examined in the following spring and autumn, they were all found to be quite healthy.

The experiments were repeated during May and June, 1916, but again with negative results.

It was, therefore, concluded that the bacteria which had been isolated from the scales of diseased bulbs were not the cause of the disease.

Infection with Fusarium bulbigenum.

This fungus was isolated from diseased bulbs and grown on sterilised potato-mush agar, it grew vigorously and produced conidia of the Monosporium and Diplocladium types. A series of experiments was then made; sixty bulbs of the varieties *Narcissus Leedsii*, *Narcissus bicolor* Barri conspicua, *Narcissus incomparabilis* Cynosure, were cut and infected with portions of agar bearing Fusarium. The Fusarium was used in three stages: (1) rapidly growing non-fruiting mycelium from the edge of a culture; (2) mycelium bearing conidia of the *Monosporium* type, and (3) mycelium with conidia of the *Diplocladium* type.

In every case the bulbs remained perfectly healthy, though the fungus was often found growing between the dead outer scales of the bulb. There was no indication that the fungus had any action on healthy bulbs. The examination of a large number of bulbs leads to the

conclusion that *Fusarium bulbigenum* is very often present on the surface of the dead and dying outer scales of healthy bulbs. It is especially abundant in bulbs which have been injured, but even on rotting scales it seldom penetrates far into the tissues. It is evident, therefore, that the presence of *Fusarium bulbigenum* is not sufficient to account for Narcissus rot.

Infection with Black mycelium.

A very dark coloured, almost black mycelium was isolated from diseased bulbs and a series of infection experiments was carried out. The infected bulbs remained perfectly healthy. It was, therefore, obvious that this mycelium did not cause bulb rot, and no attempt was made to obtain conidia or to determine the fungus.

Eumerus strigatus *and* Merodon equestris.

It has been shown by Fryer(4) that the larvae of these two insects do much harm to Narcissus plants, causing a weak, distorted growth, and the loss of a large number of plants. The damage caused by them is, however, quite distinct from the symptoms known as bulb rot.

Infection with Rhizoglyphus echinopus.

These bulb mites are very common on unhealthy bulbs, and are consequently easily obtained for experimental work. The mites were lifted off the diseased bulb with a sable brush and were gently transferred to a healthy bulb, some being put between two injured scales and some between two perfect scales. The bulbs were not planted until the mites were seen to move and were therefore presumably uninjured by the manipulation. These insects undoubtedly do a great deal of harm: they puncture the scales, and gradually cause their destruction, thus weakening the bulb; but in no case was bulb rot obtained by the use of *Rhizoglyphus echinopus*, and it seems, therefore, improbable that the mite causes the disease either by eating the bulb or by carrying bacteria into its tissues.

Infection with Tylenchus devastatrix *Kuhn.*

During the course of this investigation more than one hundred diseased bulbs have been dissected and in all of them eelworms or their eggs have been found. Small portions of tissue containing live worms were consequently easily obtained and were placed on the cut surface of the scales of healthy bulbs. Fifty bulbs infected in this way were planted in a box of sterilised soil in October and were kept in a cold frame till the following spring. By the middle of February they all

showed the characteristic symptoms of the disease under investigation, namely, precocious growth, an abnormally well-developed root system, blotches on the leaves and, above all, discoloured and rotting bulb scales. No Fusarium was observed. Another set of bulbs treated in a similar way, but planted in unsterilised soil, also developed bulb rot. Healthy bulbs, some of which were cut and the rest uninjured, were planted in both sterilised and unsterilised soil as a control; *all* these bulbs remained healthy and showed no symptoms of disease.

When these results are considered in relation to the invariable presence of eelworm in naturally diseased bulbs and to the fact that organisms, such as Fusarium and bacteria, which may be found associated with these nematodes, are unable to cause bulb rot, it becomes clear that the eelworm, *Tylenchus devastatrix*, is the sole cause of the disease.

Course of Disease.

Healthy bulbs may become infected at any time of the year provided the ground is sufficiently warm for the eelworm to be active. When the tissue in which eelworms are living becomes decayed they forsake it and pass into the ground. In a short time they infect another bulb, entering it either by the bases of the old leaves, which, as is the case with Monocotyledons, are unprotected by a callus, or by young leaves which have been injured and are just pushing up through the soil (Fig. 1). The first noticeable sign of disease in the young leaves is the appearance of pale green areas; these areas become yellow, and, then spreading downwards, produce discoloured "stripes" on the bulb scales. If such an affected portion of leaf is examined, eelworms will be found in the tissue; they lie parallel to the course of the vascular bundles and pass downwards between the cells (Fig. 2). In a few weeks after infection the tissue will contain a large number of eelworms and probably also numerous eggs. It is sometimes difficult to be certain of the presence or absence of eelworms and especially of their eggs, but both can be demonstrated easily by the following method. The material to be examined is fixed in 25 % acetic-alcohol and hand-sections are stained in Ziehl's carbol fuchsin for about an hour, the stain

Fig. 1. Infection at crown on bases of old leaves and on young leaves.

is washed out in alcohol till the plant tissue is almost colourless. By this method the eggs and worms are stained a bright red and are seen as easily in thick as in thin sections.

The infected leaf slowly dies from the tip downwards, and the eelworms, both mature animals and larvae, migrate into the lower portion of the leaf within the bulb. The dead upper portion of the leaf falls on to the ground and if the weather is sufficiently warm the eggs hatch and young larvae are soon liberated in the soil through which they can pass to a healthy bulb. Cold weather makes the eelworms sluggish, or dormant, or even kills them, and consequently checks infection.

Having once entered the bulb, either through the old leaf bases or the young foliage, the eelworms pass slowly downwards to the "plate" leaving the scales discoloured as a whole or in part. If such a diseased

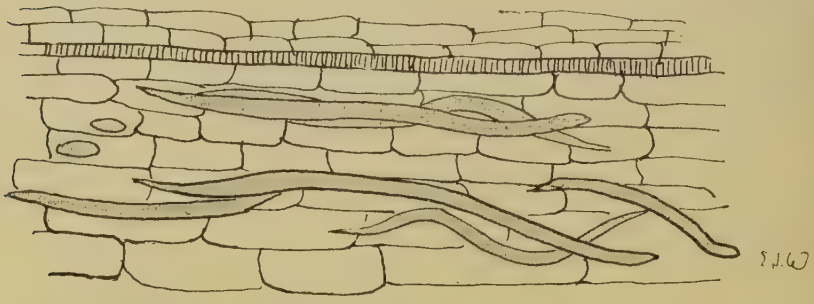

Fig. 2. Eelworms in tissue of bulb scale. ×300.

bulb is cut across transversely the discoloured scale is seen as a brown ring or part of a ring (Fig. 3). If cut longitudinally the diseased scales appear as clearly marked brown stripes (Fig. 4). It is generally the case that bulbs which have a discoloured scale have also an unusually luxuriant root system.

When the eelworms reach the plate they leave the scale down which they have travelled and enter another scale up which they make their way. Thus they are able to reach the green blades again. Blades infected in this way look quite healthy till they suddenly fall over and die. Such a stage is reached in about the month of June when whole masses of leaves may fall within a week. It is obvious that this falling of the foliage is not due to any new outbreak but merely marks a stage in a disease which has been present in the bulbs for many weeks.

As the season advances the diseased bulbs contain an increasing number of eelworms, eggs, and larvae. When such bulbs are removed

to the drying sheds many of the mature worms forsake the scales, no doubt owing to the gradually increasing dryness, and they may be found in bunches among the roots. In this position they are subjected to rapid desiccation and they soon become dormant and fall off, often on to healthy bulbs. If such worms become moistened they revive in a very short time and speedily infect the material around them. Again, if the sheds are warm, the eggs, which have been deposited in the scales, hatch and the larvae attack the tissue in which they are

Fig. 3. Diseased bulb showing ring of brown tissue.

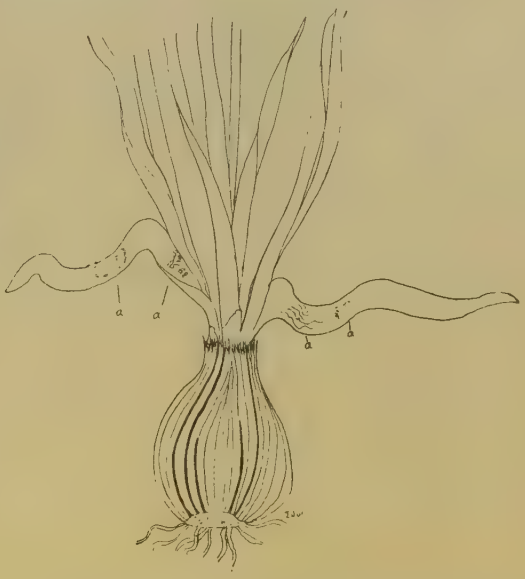

Fig. 4. Diagrammatic drawing of bulb which has been cut in half longitudinally. Second year of attack. Infection spreading up from plate. a = crinkly leaves growing at right angles to bulb.

lying. Dry, cool conditions check the spreading of the disease and prevent the occurrence of fresh infection; unfortunately such conditions are difficult to obtain in practice.

When diseased bulbs are planted in the autumn a certain proportion of them die and liberate eelworms which infect their neighbours. Those which survive start growing earlier than healthy bulbs (Fig. 5), and in the spring often produce one or more curved leaves showing crinkled

areas (Fig. 4). Owing to the large number of eelworms in such bulbs it usually happens that the disease spreads quickly, thus separating the scales from the plate; such plates bearing only roots are often found in beds in which the bulbs are very badly attacked. It seems probable that in these cases the disease has started in the previous year.

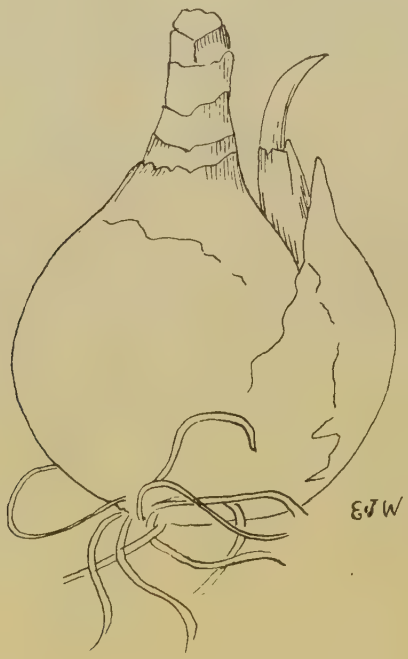

Fig. 5. Early growth of diseased bulb. August.

General Considerations.

Eelworm is well known in Europe because of the destruction it causes to various cultivated crops, especially to rye, hyacinth and onion.

Kuhn (5,6) in 1867 and 1868 described a disease in rye and showed that it was due to the action of an eelworm, *Anguillula devastatrix.*

In 1881 Prillieux (10) investigated the "ring" disease of hyacinths and attributed it to an eelworm, *Tylenchus hyacinthi.* Two years later the onion disease was shown by Beyerinck (1) to be due to *Tylenchus Allii.*

Owing to the terrible destruction of hyacinths in Holland the "ring disease," as it is called, has been thoroughly studied in that country, more especially by de Mann (7) and by Ritzema Bos (2,3). The latter believes that the slight differences which exist between the eelworms parasitic on rye, hyacinth, onion and numerous other plants are not of specific value but are due to environment. He considers that the eelworm present in these plants should be called *Tylenchus devastatrix*, Kuhn, and he publishes a diagnosis of the species with a detailed description and numerous figures (III. pp. 185, 220). As the characteristics of the eelworm found in Narcissus bulbs in England agree exactly with the diagnosis of *Tylenchus devastatrix* as given by Ritzema Bos, there seems no doubt of the correctness of the identification here put forward.

According to Ritzema Bos (III. pp. 232–234), *Tylenchus devastatrix* attacks a variety of cultivated and wild plants, and though it is capable of passing from one to the other it does not do so easily. He concludes that there are physiological varieties of the species and says: "Il paraîtrait donc qu'on peut admettre comme règle, que le *Tylenchus devastatrix* se fixe dans les plantes dans lesquelles les ancêtres ont vécu depuis plusieurs générations, de préférence à d'autres espèces de plantes; et que, toutes choses égales d'ailleurs, il préfère ordinairement la plante ayant une parenté étroite avec celle dans laquelle vivaient les générations précédentes, à celle qui en est plus éloignée dans le système.

"J'estime qu'on pourra trouver dans ce qui précède la clef de bien des choses, inexpliquées jusqu'ici relativement à l'apparition et à la disparition des maladies vermiculaires dans nos cultures.

"Il résulte d'ailleurs de ce qui a été traité jusqu'ici dans ce chapitre, que, si au point de vue *morphologique* il faut considérer comme une espèce unique les *Tylenchus* des jacinthes, ceux de l'oignon, ceux du seigle, du sarrasin, du trèfle, etc., et ceux de la mousse *Hypnum cupressiforme*, il existe néanmoins des différences *physiologiques* entre les différentes *Tylenchus*, selon que leurs ancêtres ont vécu durant un grand nombre de générations, dans telle ou telle plante."

The differences between the eelworms of hyacinths and of onions indicated by Ritzema Bos suggest a comparison with the "biologic forms" described for various parasitic hosts. It is to be noted, however, that Ritzema Bos ascribes to the eelworms merely *preferences* for their original host while the biologic forms are normally confined by physiological differences to their particular host or set of hosts. The physiological differences between the onion and hyacinth "forms" of eelworm,

if they exist, are obviously less definite than those which differentiate the biologic forms of the Uredineae and of the Erysiphaceae.

If the eelworm of Narcissus follows the behaviour described by Ritzema Bos for that of the hyacinth and of the onion it is clear that while the bulbs are in the ground there is very little fear that it will migrate to neighbouring weeds. However, directly the bulbs are lifted any eelworms remaining in the ground are likely to migrate to suitable weeds[1] which thus would become valuable traps. It is desirable, therefore, that before replanting the ground all weeds should be removed and burnt; weeds should never be allowed to wilt on the soil nor should they be dug in.

A list of the more common British weeds and cultivated plants which have been described as affording shelter to *Tylenchus devastatrix* is given here. It is compiled from papers of Ritzema Bos(2,3); it has no claim to completeness.

Medicago sativa
Trifolium pratense
Polygonum fagopyrum
,, convolvulus
,, persicaria
,, lapathifolium
Bellis perennis
Ranunculus acris
Geranium molle
Sonchus oleraceus
Myosotis stricta
Plantago lanceolata
Poa annua
Holcus lanatus
Brassica rapa
Anthoxanthum odoratum
Centaurea jacea
,, cyanus
Spergula arvensis
Allium cepa
,, proliferum
,, vineale
,, schoenoprasum
Hyacinthus romanus
,, orientalis
,, precox
Tulipa gesneriana
Lilium candidum
Fritillaria imperialis
Galtonia candicans
Scilla sibirica
,, campanulata
,, cernua
Narcissus Tazetta
,, Pseudo-narcissus
Muscaria botryoides
,, comosum
Humulus lupulus
Phlox
Chelone glabra
Solanum tuberosum
Wheat
Rye
Oats
Vicia Faba

[1] The question of the occurrence of migration and its extent would be well worth investigation.

Ritzema Bos found eelworms in some plants of *Narcissus Tazetta* which he had planted in soil infested with the eelworm of barley, but he states that bulb growers in Holland find that Narcissus bulbs do not suffer from bulb rot. He says (III. p. 230) "J'appris aussi par des cultivateurs de bulbes à fleurs de Haarlem, que les tulipes, les lis, la couronne impériale et les narcisses ne sont jamais atteints de la maladie causée par les anguillules (maladie annulaire)."

Thus in 1887 it is clear that the eelworm disease of Narcissus was little known in Holland though it was then very prevalent among Hyacinths.

The occurrence of eelworm disease in Narcissus is mentioned by Marcinoswski(8) in 1910 but no account is given of it and it seems reasonable to conclude that though it was recognised in Holland in 1910 it was comparatively rare.

Hewitt(4A), working in Ireland, seems to be the only other investigator who has described the occurrence of *Tylenchus devastatrix* in Narcissus bulbs. His paper is short and deals mainly with the action on the bulb and organism of various "steeps." In the light of our present knowledge it is clear that he was dealing with "bulb rot"; but his description of the diseased condition is so brief that apart from the nature of the infecting organism the nature of the disease he describes would remain uncertain.

The account given here of the cause and progress of the bulb rot of Narcissus shows that certain precautionary measures will check to some extent the ravages of the eelworm. Such measures may briefly be summarised as follows:

(1) Narcissus should not be planted in ground previously infected with *Tylenchus devastatrix*; the danger is especially great if the eelworms have been liberated from a previous crop of Narcissus.

(2) Care should be taken to plant healthy bulbs only; one diseased bulb will soon infect many others.

(3) When a bulb does not produce foliage at the proper time it should be dug up and burnt before it rots and liberates eelworms in the soil.

(4) Bulbs with "crinkly" or very curved leaves should be burnt.

(5) Dying leaves should be gathered and burnt before they can fall on the soil and so possibly infect it.

(6) Weeds growing in infected soil should be pulled up, put directly into baskets, and burnt.

SUMMARY.

The bulb rot disease, or ring disease, of Narcissus is due to the attack of an eelworm, *Tylenchus devastatrix*. These eelworms are of constant occurrence in the diseased bulbs, and the disease can be produced by infecting healthy plants with the eelworm.

A description is given of the symptoms and course of the disease as it appears in nature, and certain precautionary measures are suggested.

I have great pleasure in expressing my thanks to Mr J. W. Barr (Messrs Barr and Sons), Mr Hales (Chelsea Physic Gardens), Mr Leake (The Floral Farms, Wisbech), Mr Pearson (Messrs J. R. Pearson and Sons), and Mr J. Walker (Walker Bros.) without whose cordial co-operation and generous help the work could not have been carried out. I am also indebted to Mr J. C. Fryer for help and suggestions with regard to treatment.

I should also like to take this opportunity of thanking both Professor V. H. Blackman and Professor J. B. Farmer for their stimulating and helpful criticism.

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NOTES ON A PLAGUE OF PSOCIDS IN A FACTORY.

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The small insects belonging to the family Psocidae cannot as a whole be regarded as injurious either to growing plants, or to plant products in their manufactured state. Their food is said to consist for the most part of minute fungi, such as moulds, and of animal or vegetable refuse[1], and they, therefore, are seldom attracted to any material of value.

From time to time, however, Psocids are recorded as being destructive to such objects as corks, books, insects in collections, etc., and in most cases it seems likely that the objects attacked had been kept in damp surroundings and were, therefore, affected with moulds or other fungi. An instance is mentioned by Theobald, for example, in which the Psocid *Atropos divinatoria* was referred to him with the complaint that it was appearing in large numbers from an old mattress, and "causing some consternation[2]."

The genera most often associated with this type of damage are *Atropos*, sometimes known as "Book Lice" (owing, doubtless, to the fact that they are frequently found in the neighbourhood of old books or papers which have not been disturbed for some time), and *Caecilius*, but it seldom seems to have been recorded that either has been responsible for serious loss from the financial point of view.

It may, therefore, be of interest to describe a case in which a stoppage of work in an important factory where straw mattresses are made was actually brought about by insects of the genus *Caecilius* (*C. pedicularius*[3]). These psocids had established themselves to such an extent that when

[1] *Cambridge Natural History*, vol. v, p. 393.

[2] Report on Economic Zoology for the year ending September, 1910, in *The Journal of the South-Eastern Agricultural College, Wye*, No. XIX.

[3] Specimens were submitted to Dr Gahan of the British Museum of Natural History, who kindly identified them as belonging to this species.

the large double doors of part of the building, referred to below as the "loft," were opened in the morning, they could be seen flying out in thick clouds. When, further, complaints began to be made by customers about large numbers of insects appearing in bedrooms where newly purchased mattresses were being used, the manager of the factory recognised the seriousness of the outbreak, and wrote a letter to the writer, requesting advice as to how to get rid of the pest.

In order to ascertain the nature of the buildings and the manner in which the straw for making the mattresses was being stored, a visit was paid to the factory, when it was found that three buildings were involved, viz.

(*a*) the loft, in which the straw was stored,

(*b*) the making-room, in which the mattresses were made,

(*c*) the store-room, where the finished mattresses were stored.

The insects were most numerous in the loft, which measured 18½ feet high, by 28 feet long, by 15 feet wide, the other rooms being slightly less. No fresh straw had been brought in after the old had been used up, so that the nature of the flooring could be easily examined. It was of concrete, and there were a few fairly wide cracks running across the whole width. In these cracks immature forms of Psocidae were observed.

The measures successfully adopted to get rid of the pest may be put briefly as follows:

(1) The ventilators in the loft were closed, and all crevices (round the doors, etc.) were covered over with paper carefully pasted on—the door through which the fumigant was admitted being dealt with immediately after being closed.

Ten pounds of rock sulphur (previously broken up in a sack by means of a mallet) were placed in an iron pot, and some hot cinders thrown on top. The pot was placed in the middle of the room, and instructions were given not to open the doors until twenty-four hours had elapsed. The other rooms received similar treatment.

(2) The loft having been thoroughly ventilated after fumigation, the walls were then carefully whitewashed (the whitewash containing some carbolic acid) and the floors of all the rooms were washed out with water and carbolic soap.

(3) It seemed probable that a few Psocids might appear in a week or two, seeing that the eggs might not be affected by the treatment, and, indeed, six days after the fumigation, a report was received stating that the insects were beginning to reappear. The writer accordingly visited

the factory and found a few Psocids mostly near the windows—in quite a sufficient number to start another plague of them. It was, therefore, decided to repeat the treatment, but to use fifteen pounds of sulphur instead of ten pounds for the second fumigation. After twenty-four hours' fumigation, the floors were again washed out with carbolic soap, and creosote was carefully poured down, along the cracks in the floor of the loft. The manager was recommended to close up these cracks with cement, after this second fumigation.

Six weeks afterwards a letter was received from the manager in which he said: "I am pleased to be able to tell you that there has not been a recurrence of the plague of flies," and a recent examination of the buildings showed that the treatment had been successful. The cracks had been closed up with cement as recommended.

With regard to the probable source of the outbreak it should be mentioned that straw coming in from one of the farms supplying the factory was dirty and in bad condition. The supply of straw from the particular farm was stopped when it was pointed out that this was most probably the source of the trouble, and the writer recommended that care should be taken to secure good clean straw in future. It seems, therefore, likely that the continued freedom from the pest now for nearly six months, is due to this precaution following upon the measures taken against the insects that had succeeded in establishing themselves in the factory.

Although the Psocids do not attack man, it is interesting to record that in the case of the above outbreak, an eruption appearing on the skin of a child sleeping in a bedroom containing a newly purchased mattress from which the insects were emerging, was not unnaturally attributed by the mother to the presence of the Psocidae.

A BACTERIAL BLIGHT OF PEAR BLOSSOMS OCCURRING IN SOUTH AFRICA.

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(With 7 Text-figures.)

During the seasons 1914—15 it was observed by fruit growers in the Stellenbosch district that a large percentage of the pear blossoms blackened and then died, and that in some varieties only a very small number of mature fruits were produced. The blackening was at first attributed to *Fusicladium*, but winter spraying seemed to have no effect on the prevalence of the trouble and specimens were therefore sent to this Laboratory for examination. The discoloured tissues were found to be swarming with innumerable bacteria; from these a pure culture was readily obtained of an organism which caused blackening in pear blossoms, artificially inoculated within a few days. The organism was re-isolated, and studied with a view to comparing it with the two organisms which are known to cause blight in fruit blossoms and which will be referred to in detail presently; one of these is the well known "Fire Blight" organism, *Bacillus amylovorus*, which occurs commonly in America, and the other a *Bacterium* recently described by Barker and Grove, as causing a blight of fruit blossoms in England. The South African organism proved to be distinct from either of these.

It is interesting to note that during some experiments carried out at the Elsenberg Agricultural College, in an orchard which has since been found to be heavily infected with the blossom blight, it was found that if the flowers were covered with paper bags before they opened almost 100 % set, as many as 32 to one truss in some cases; whereas when the flowers were not covered a large percentage fell. This was attributed to the fact that the blossoms were sheltered by the bags from high winds and sudden changes of temperature, but it seems more probable that it was due to the flowers being protected from the

visits of bees and other insects which have been shown both in this case and in the case of other diseases of a similar nature to be the principal carriers of infection.

Comparative Schedule.

	Bacillus amylovorus	Barker and Grove's Organism	*Bacterium nectarophilum*
Dimensions	·9—3 μ × ·7—1 μ	2—4 μ × ·5—·8 μ	·5—3 μ × ·45—·7 μ
Flagella	Several peritrichous	Polar 3—6	Polar 1—5
Capsule	None	None	Always present
Optimum Temp.	25—30° C.	15—18° C.	25—30° C.
T. D. P.	43·7° C.	—	40° C.
Pigment	None	Some fluorescence in old cultures	Fluorescent
Agar colonies	White, circular, elevated, wet, shining, margins irregular	Whitish, circular, smooth margins	Spreading, irregular margins
Nutrient Broth	Clouding not heavy, pellicle and rim slight, moderate amount of grey deposit	Well clouded, appreciable deposit and slight rim and pellicle	Very turbid, deposit heavy, rim and pellicle present
Gelatine Stab	Slow crateriform liquefaction	Liquefaction rapid, first crateriform then stratiform	No liquefaction
Milk	Coagulated in 3—4 days, later digested to pasty condition	Slowly peptonised	Slowly peptonised
Vegetable Cylinders (Potato, Carrot, Turnip, Beet)	Good growth on all, best on beet, weakest on turnip, liquid heavily clouded	Fair on potato, feeble on carrot, none on turnip	Fair growth on all but heavy on none
Uschinsky's solution	Growth copious, not viscid	No growth	Heavy, viscid growth
Indol	Considerable quantity produced	Reaction only obtained after warming	None produced
Diastatic activity	Strong	Feeble	Feeble
Group numbers	221,232201	221,3332123	222,2332123

During September, 1916, I was able to visit the pear-growing district, and to study the disease in the orchard; it was too early for the late-flowering varieties, some of which are the most susceptible, but considerable infection was found in the Keiffers and other varieties which were then in flower. Information as to the susceptibility of the different varieties was also gleaned from various growers, all of whom mentioned the same varieties as the most liable to the disease.

Pear trees flowering in the Wellington District and in the Pretoria District show no signs of the blackening: a trouble of a somewhat similar nature has been reported from Potchefstroom, but it has not

yet been ascertained whether this is identical with the blight at the Cape or not. With the exception of a case of infection reported from Wynberg, therefore, the disease is only known to occur up to the present in the Stellenbosch District and at Elsenberg. It is particularly interesting to find that there are three organisms showing a parasitism, in many respects similar, in different parts of the world; it is therefore my intention to describe the South African disease, and to compare it with the blossom blight occurring in England and with that caused by the fire blight bacillus in America.

Through the courtesy of Professor Barker and Mr Grove who supplied me with a culture of their organism I have been able to make a detailed comparison of the South African and English bacteria. My knowledge of the American blight is less complete, being gathered from the literature to which I have access, and which is by no means exhaustive; sufficient information has been gathered by this means, however, to establish the main points of difference between *Bacillus amylovorus* and the other organisms causing blossom blight in pears.

I. Fire Blight.

Bacillus amylovorus (Burr) de Toni.

The information summarised in the succeeding paragraphs has been derived from the publications listed in the "Literature cited" (numbers 4—11).

"Fire blight" was one of the first bacterial diseases of plants to be recognised as such, and consequently has been studied in considerable detail. It is very widely distributed in the United States and in Canada, and has recently been recorded(8) from several places in Italy. It causes very serious losses, amounting in California in the last fifteen years to one-third of all the full-grown orchards, and to a money loss estimated at $10,000,000 for the five years preceding the efforts for its restriction begun in 1905 by the United States Department of Agriculture(8).

In 1912 a variety of pear in Switzerland was severely injured by a bacterial invasion(7). It is thought that the disease may be similar to the pear blight in America caused by *Bacillus amylovorus*, but complete identification of the organism has not yet been found possible.

Although most common and most disastrous on the pear (*Pyrus communis*) *Bacillus amylovorus* is also found as a parasite on the apple (*Pyrus malus*), Quince (*Cydonia vulgaris*), a number of species of *Prunus*

including the plum and apricot, and on numerous plants indigenous to America. Of the varieties of Pear which was attacked, the Bartlett is said to be very susceptible; other varieties are bracketed with the Bartlett as susceptible, but there seems to be considerable divergence of opinion on this point. The Keiffer, Duchess and Winter Nelis, and the oriental group in general are more resistant.

Symptoms.

Although infection most frequently takes place through the flowers, the blossom blight is not by any means the most serious phase of this disease. When the blossoms are attacked the receptacle becomes blackened first, infection taking place through the nectaries, but the infection rapidly spreads into the ovary and the flower stalk and invades the twigs. The blossoms and leaves of affected twigs become discoloured, turning light or dark brown, or sometimes red, and finally shrivel up and die. The spread of infection is frequently so rapid as to result in the complete blackening and death of all branches and spurs upon which flower clusters have been borne. The blight may continue to extend down the branch or twig, the branch being entirely killed as it progresses, and in course of time it may extend into the larger limbs. The bark of infected twigs and branches becomes blistered, and on the blistered areas there is often found a gummy exudate which is crowded with the rods of the causal organism; this exudate attracts the insects which are responsible for the further spread of the disease. Immature fruit is frequently attacked; it becomes light brown and finally black, the flesh soft and pulpy, and the skin somewhat wrinkled. Ripe fruit seldom becomes infected.

The Characters of *Bacillus amylovorus* (Burr) de Toni.

Morphology.

Bacillus amylovorus is a short rod with rounded ends, ·9—1·5 μ × ·7—1 μ in dimensions, longer (nearly up to 3 μ) and slightly narrower in old cultures.

It is motile by means of several (4—8) peritrichous flagella; no capsules or spores have been observed. The rods are usually single or in pairs, but in young cultures short chains made up of 3 4 individuals have been noted.

The organism is Gram-positive.

Cultural Characters.

Nutrient agar colonies are evident on the second and attain a diameter of 2—3 mm. by the fourth or fifth day. They are white and granular, or cloudy with a sharply defined white centre; the margins are entire or slightly wavy. Submerged colonies are opaque, yellowish-white, lenticular.

Nutrient agar stab. Growth takes place along the entire length.

Nutrient agar streak. In 24 hours there is a moderate opalescent growth which spreads slowly. It is finally white, wet-shining, thin along the middle, heavier along the sides, margins wavy, eventually spreading over the surface of the slant. More rapid growth is induced by the addition of the agar of 2 % saccharose, dextrose or maltose or 5 % glycerine. The water of condensation becomes turbid, but the growth is not viscid.

Nutrient gelatine colonies are very slow growing, only appearing after 3—5 days. The surface colonies are round, slightly raised, entire, buried colonies spherical, granular. The medium is liquefied very slowly.

Nutrient gelatine stab. Growth is at first filiform, and is slow and feeble; surface growth spreading with irregular margin; slow crateriform liquefaction takes place, later becoming stratiform.

Nutrient bouillon is clouded after 24 hours and this is accompanied by a slight acidity; after 48 hours there is greater cloudiness with more or less persistent flocculi, the medium becoming alkaline, and in time showing a tendency to clear. In sugar-free bouillon the liquid remains clear for 24 hours except for a slight sediment. It is neutral at first, becoming cloudy and alkaline after some days. The clouding is never very heavy as compared with other organisms.

Milk is coagulated in 3—4 days; coagulation is followed by digestion to a pasty or sub-gelatinous condition, with separation of supernatant whey; this is at first acid, later becoming slightly alkaline. Litmus milk is unchanged.

Blood serum. On this medium the growth is similar to that on nutrient agar; there is no liquefaction.

Potato, carrot, turnip, beet. There is good growth on all these media; it is best on beet, weakest on turnip. In all alike a wet-shining white streak forms along the line of inoculation: the liquid is heavily clouded, white and nearly opaque. The tissues are not softened and there is no odour, gas or pigment.

Cohn's solution. No growth.

Dunham's solution. The organism grows rapidly in this solution, but the clouding is not dense; there is no pellicle or rim and the deposit is slight.

Uschinsky's solution. Growth copious but not viscid.

Biochemical and Physical Relations.

Enzyme production: Amylase. Amylolytic activity is indicated by the fact that the organism liquefies starch jelly.

Gas. No gas is produced in fermentation tubes with glucose, saccharose, lactose, glycerine, maltose or mannite.

Pigment. None, organism is white or greyish white on all media.

Indol. A considerable amount of indol is produced.

Acid and *alkali production.* Ordinary nutrient broth shows a slight decrease of alkalinity, then a return to the original reaction. Broth containing 2 % saccharose or glucose, gradually became acid; lactose broth showed little or no change in two weeks.

Nitrates are not reduced to nitrites.

Colour reduction. Litmus milk and rosolic acid peptone water showed progressive bleaching during the first week, but the colour finally returned.

Toleration of sodium chloride. 3 % did not inhibit growth.

Temperature relations. The optimum temperature is 25—30° C.; there is no growth at 5° C.; growth is very slow at 3° C. Thermal death point (wet) is 43·7° C., 10 minutes exposure.

Desiccation. When organism was dried on cover glasses at about 20° C., 5 days had no effect, 76 days was fatal.

Insolations. 10 minutes exposure of freshly poured plates retarded development; 30 minutes was fatal.

II. Blossom Blight in England caused by Barker and Grove's Organism.

This disease is very widespread in England, probably occurring at least throughout the midland and southern counties. The most susceptible varieties are the Beurre d'Amanlis and the Catillac.

The method of infection varies; sometimes the sepals turn grey and blacken, the discoloration finally involving the whole of the calyx and flower stalk, and the flower blackens and shrivels up. It may then fall or it may remain attached to the shoot. The whole truss

of blossom eventually dies and the spur may also die back to its point of attachment to the branch carrying it. In other cases infection takes place through the receptacle, which becomes blackened, the discoloration spreading to the ovary.

The disease is carried from flower to flower by bees. An organism has been isolated and the disease reproduced repeatedly by Barker and Grove in the course of their study of the disease; and I was successful in producing black spots on the receptacle with the culture which they sent to me; these latter developed rather slowly as the room temperature was far above the optimum for the organism.

In a recent report (2) it is stated that an organism has been isolated from diseased gooseberry bushes which is in all probability identical with the organism causing the pear blossom blight.

The Organism.

A parallel series of cultures of this and the South African organism have been carried out; the characters of Barker and Grove's organism are described in some detail in their paper (1) but a few additional points of interest have been observed in making the comparative study, which may be added to their description.

Morphology.

The organism is a rod 2—4 × ·5—·8 μ, the cells are mostly single or in pairs, seldom in long chains. It is highly motile in young cultures by 2—5, lophotrichic flagella (Fig. 1) which are four to five times as

Fig. 1. Barker and Grove's organism 24 hrs. at 20° C. Ellis' flagella stain. Zeiss obj. $\frac{1}{12}$, No. 12 compensating ocular. Drawn with the aid of the camera lucida.

long as the rods. No capsules have been observed. Involution forms are produced in 24 hours in nutrient broth at 30° C. and in old cultures; these take the form of long threads up to 100 μ long and irregularly swollen.

It stains well with all the usual stains, especially with Gentian violet and is Gram-positive.

Cultural Characters.

Nutrient agar colonies. At 18°—20° C. the colonies are visible to the naked eye in 48 hours; in three days the surface colonies are ·5 to 3 mm. in diameter, round-irregular, glistening and translucent; in four days they are up to 5 mm. in diameter, of a light coppery tint by transmitted light, creamy white by reflected light. Some of the colonies are inclined to spread and become lobulate, but the majority are more or less circular, with a smooth margin.

The submerged colonies are at first punctiform, afterwards lenticular. There are a few crystals in old cultures.

Nutrient agar streak. Cultures form a flat, whitish glistening growth, spreading out at the base of the slant; very old streaks are slightly fluorescent.

Nutrient agar stab. The best growth is at the top.

Nutrient gelatine colonies. Visible in 48 hours; the submerged colonies are minute white points; those on the surface slightly larger, with an undulate margin around which there is a slight indication of liquefaction. After four days the surface colonies are sunk in small craters of liquefied gelatine, they are moist and glistening semi-transparent, often with a small white nucleus in the centre, surrounded by several concentric rings of whitish, granular matter. Liquefaction of the gelatine is complete in 8—10 days.

Nutrient gelatine stab. In three days at 18—20° C. there is a small crater of liquefaction 4—8 mm. broad and 8—10 mm. deep, and the surface growth has sunk to the bottom of the crater; in seven days the liquefaction involves the whole thickness of the tube and becomes stratiform.

Potato. On this medium there is a raised, creamy-white growth with smooth edges along the needle track.

Turnip. No growth.

Carrot. The growth on carrot is very scanty, thin, and spreading.

Parsnip. A very much raised, shining streak develops, standing

about 2 mm. high, the surface being almost semi-cylindrical; on one cylinder the edges only were raised and the centre depressed.

Beet. On beet the organism grows fairly well, producing a raised, gelatinous-looking growth along the needle track; the growth on the surface of the liquid takes up the colour from the medium to some extent and becomes fairly pink.

Blood serum. The organism does not liquefy blood serum, and the streak is similar to that on nutrient agar, but the growth less copious.

Nutrient bouillon becomes slightly clouded in 24 hours, and in two to three days is fairly heavily clouded. There is a considerable amount of sediment and a very thin pellicle. In very old cultures a slight fluorescence may sometimes be observed.

Milk is not curdled, but is very slowly peptonised. In nine days two-thirds to four-fifths of the liquid is clear; after one month the milk is completely peptonised, the colour is reduced in litmus milk, and the medium is distinctly alkaline to litmus.

Dunham's solution is slightly clouded.

Uschinsky's solution. No growth.

Cohn's solution. No growth.

Nutrient bouillon over chloroform. Growth was unrestrained in the presence of chloroform.

Egg albumen. A medium composed of 1 gram powdered egg albumen and 50 c.c. of ·05 % potassium phosphate was well clouded in five days.

Physical and Biochemical Relations.

Proteolytic activity. The organism is a fairly active proteolytic agent; it slowly peptonises milk and there is a distinct smell of ammonia from liquefied gelatine.

Cultures in nutrient bouillon were tested for ammonia by distillation after five to 10 days at 20° C. In each case 50 c.c. of medium were found to contain approximately ·02 gramme of ammonia nitrogen.

In the egg albumen medium described above there was a positive reaction for peptone after five days. A quantitative test by Sorensen's method showed that 50 c.c. of the medium after five days contained ·0035 nitrogen, in the form of amino acids and ammonia, *i.e.* approximately 2·3 % of the total nitrogen had been broken down. A distillation test for ammonia showed that the whole of this was in the form of ammonia; and cultures tested after 10 days gave an almost identical reading; the amount of ammonia had not increased.

Milk cultures tested in the same way gave a strong reaction for peptone and for tyrosin after 10 days; and there was ·011—·017 grains ammonia nitrogen in 50 c.c. of the medium.

Amylolytic action. Starch is very slowly destroyed; nutrient bouillon containing ·01 gram of soluble starch gave the red-brown reaction of amylodextrin with Lugol's iodine solution after about 10 days, and in three weeks the starch had completely disappeared.

Fermentation reaction. No acid or gas was produced in fermentation tubes containing peptone water, tinted with litmus, and containing 2 % of any one of the following substances:—starch, laevulose, mannite, glycerine, galactose, saccharose, dextrose, lactose.

Indol. No reaction for indol was obtained at room temperature in 10 days old cultures in peptone water and nutrient broth, but after warming a slight, but quite definite coloration appeared after the addition of sulphuric acid and a nitrite.

Nitrates are not reduced to nitrites.

Gas production. It has been mentioned that no gas is produced in fermentation tubes containing sugar solutions. In iron and lead peptone solution and bouillon the precipitate was decidedly blackened, showing that sulphuretted hydrogen had been liberated.

Atmospheric conditions. The organism is a facultative anaerobe; it grows slowly on glucose formate agar in an atmosphere devoid of nitrogen.

Temperature. The optimum temperature lies between 15 and 20° C.; the thermal death point has not yet been determined.

III. The South African Disease.

It has already been pointed out that so far as is known at present the pear blossom blight only occurs in the Stellenbosch District and at Elsenberg, that is to say in the region where the winter and early spring is the rainy season and in that part of it where pears are extensively grown. Several cases of blackening in blossoms and pearlets grown in other parts of the country have been brought to our notice, but as these occurred in hot dry weather after some six or seven months' drought, it is more probable that the failure of the blossoms was due in these cases to drought than to the bacterial blight, which only spreads rapidly when the atmosphere is moist. Further investigation, however, will be necessary before any definite statement as to the geographical distribution of the disease can be made.

Varieties affected.

Some of the late flowering varieties are the most susceptible. Winter Nelis and Beurre Superfine are very badly affected, also the Kastanje Bergamot; a number of other varieties including the Keiffer, Beurre Diel and Bon Chrétien are also affected but not to the same extent as those above mentioned. The Duchesse d'Angoulême appears to be practically immune, as no sign of the disease could be found on trees standing in an adjacent row to a number of Keiffers which were badly affected.

Symptoms and spread of infection.

So far as can be ascertained up to the present the disease is confined to the flowers, peduncles and very young fruits. No infections have as yet been found on leaves or twigs, and I have failed to produce artificial infections on these parts.

Infection almost invariably takes place through the receptacles; it usually takes place at more than one spot, a number of minute dark spots appear on the receptacle, these rapidly increase in size, becoming black and spreading until the whole receptacle is involved. Less frequently the tissues of the receptacle are very completely invaded before any blackening occurs, the whole assuming a greenish brown, water-soaked appearance and later turning black.

When the receptacle is invaded the infection and blackening frequently spreads to the styles and the ovary, and less frequently to the flower stalk. Infected flowers fall, and in the case of susceptible varieties in such numbers as to seriously affect the crop.

The rapidity with which the disease spreads from flower to flower suggested that the infection is carried through the agency of bees. With the assistance of Mr Neethling, the lecturer in Botany at the Elsenberg Agricultural College, this point was satisfactorily settled. He kindly co-operated with me in this matter by capturing a number of bees which were working in the neighbourhood of the infected trees; some of these were allowed to walk over some nutrient agar and then released; from others the mouth parts were excised, and dropped into tubes of melted agar which were then set on the slant. The tubes thus infected were then posted to me at Pretoria for examination.

Cultures of the causal organism were readily obtained from all five of the tubes containing the bee traces; of the others the organism was found in one into which the head and prothorax of the bee had been

dropped, but not in any of the tubes planted with the proboscis or mandibles alone.

Artificial infections were readily produced with the culture isolated from the bee traces.

It seems possible that ants may also be partly responsible for carrying infections, as quite a number of them were noticed working in the infected flowers at one farm in the Stellenbosch District.

Etiology.

When the organism causing the bacterial blight in pear blossoms was first isolated in October 1915, the blossoming season in Pretoria was almost at an end, but a preliminary infection experiment was carried out with the few flowers which were still to be found on the trees. The blossoms sent from Stellenbosch were shrivelled and quite black, but bacteria were very plentiful in the tissues and no difficulty was experienced in obtaining a pure culture.

The weather was exceedingly hot and dry so that it was useless to attempt any inoculations in the orchard. A number of twigs bearing apple and pear blossoms were therefore carefully cut under water, and conveyed to the laboratory where they were covered over with bell jars; some of these were atomised with a suspension of a culture in sterile distilled water, others kept as controls. The latter remained fresh and showed no signs of drooping or discoloration during the experiment. The inoculated blossoms, however, showed water-soaked spots on the petals, calyx, and peduncle after 24 hours; in 48 hours these had become very numerous and began to turn brown, and in a few days the whole flower had turned black and fallen.

The organism was readily re-isolated and inoculated into some young pears by atomising as before; a few infections were thus obtained in pearlets which had just set, but not on the fruit of the size of a walnut or larger; that is to say, the organism seemed unable to attack the young fruit after it had begun to harden.

After visiting the affected orchards in September, 1916, fresh cultures were obtained from material collected, and a number of inoculations were carried out with the organism thus freshly isolated, the strain isolated the previous year and with Barker and Grove's organism. Inoculations were carried out in one of three ways; the flower was infected by touching the receptacle with a platinum needle, which had been charged with a small quantity of agar culture; a drop of a suspension of an agar culture was placed on the receptacle with a fine pipette;

or the whole inflorescence was atomised with a suspension of an agar culture in distilled water.

When either of the first two methods was employed a number of minute water-soaked spots appeared on the receptacle in 24—48 hours, or, in the case of a heavy infection the whole receptacle became water-soaked in appearance.

The infected areas soon began to turn brown and spread until the whole receptacle was involved. The receptacle was finally quite black, the blackening not infrequently spreading into the styles, ovaries and peduncle: and the slightest movement was sufficient to cause the infected flowers to fall.

When the inflorescence was atomised, infection was equally prompt, discoloured areas appearing on the sepals, petals, ovary and peduncles. In no case have I been able to infect the leaves or fruit spurs, and I have not observed any such infections in the orchards.

All inoculations were carried out in the Laboratory under conditions similar to those employed during the preliminary experiment carried out in 1915; a schedule of the inoculations is appended.

It will be noticed that positive results were obtained in each case when pear and apple blossoms were inoculated, but that attempts to infect cherry, peach and nectarine were all unsuccessful. Up to the present no natural infections on the apple have been found.

In each experiment an equal number of flowering branches were kept as controls: and in no case did the disease appear in these.

No.	Kind of Blossom	Method	Source of Culture	Results
1	Pear	Atomiser	Blossoms from Banhoek, Stellenbosch	Positive
2	Apple	„	„ „	„
3	Pear (young fruits)	„	Re-isolated from (1)	„
4	Pear	Platinum needle	Blossoms from Elsenberg	„
5	„	Pipette	„ „	„
6	„	Atomiser	„ „	„
7	Cherry	Pipette	„ „	Negative
8	Pear	„	As (1) but after 12 months in cultivation	Positive
9	„	„	Blossoms from Ida's Valley, Stellenbosch	„
10	„	„	Re-isolated from (4)	„
11	„	Atomiser	Same as (4)	„
12	Peach	Pipette	„ „	Negative
13	Nectarine	„	„ „	„
14	Pear	„	„ „	Positive
15	„	„	Bee traces	„

Pathological Histology.

Infection usually takes place through the nectaries, but the organism sometimes finds its way into the green tissues of the flower and flower stalks through the stomata.

The rods multiply very rapidly in the intercellular spaces, and it is very noticeable that wherever the intercellular spaces are invaded, the contents of the adjacent cells become plasmolysed and stain very deeply with carbol fuchsin. In sections stained with carbol fuchsin and light green these showed up in startling contrast to the normal cells which stained light green and in some of which the nucleus could be plainly seen (Fig. 2).

Fig. 2. Section through diseased receptacle, natural infection, drawn with Edinger's projection apparatus. An early stage of infection.

After the cells are plasmolysed and killed they disintegrate very rapidly and collapse, the original cell outline completely disappears and the diseased area consists of a disorganised mass staining intensely with carbol fuchsin.

When the receptacle is infected the flowers soon fall, but in some cases not until the infection has spread into the more deep-seated tissues of the ovary, all of which become blackened and disorganised (Fig. 3).

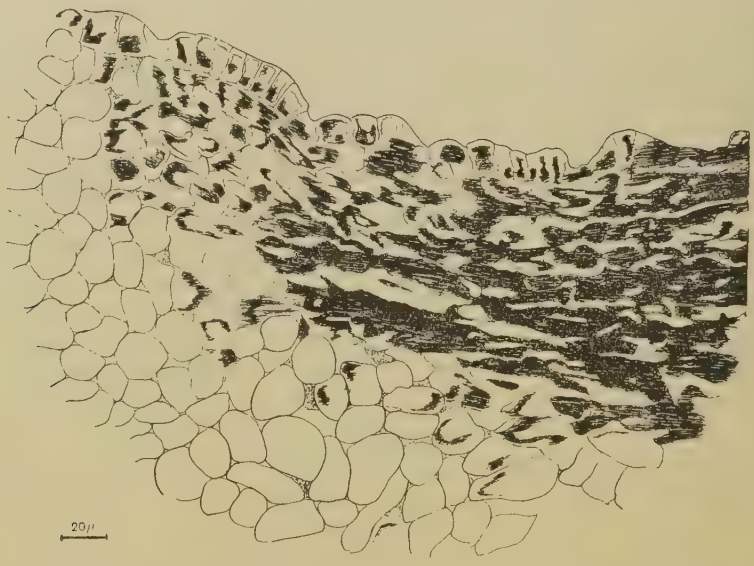

Fig. 3. Section through diseased receptacle, natural infection, drawn with Edinger's projection apparatus, the scale is indicated. A more advanced infection showing the collapsed tissues.

Morphology.

The organism is a short rod of very variable size and shape. A pure culture may be readily obtained from infected tissues, but the milky white masses of bacteria which diffuse out from such tissues consist of rods which exhibit astonishing variations in size and form (Fig. 6). The majority are short thick rods with rounded ends, measuring for the most part ·6—1·5 × ·5—·7 μ, but all the variations found on various culture media may be seen. In addition to these there are undivided rods up to 12 μ long, which are sometimes irregular in shape but which stain intensely with carbol fuchsin; it would seem probable that these are involution forms of some sort, although nothing resembling them has been found in artificial culture media. The same remark applies to fairly numerous rods of various lengths which stain faintly and are only about ·2 μ in diameter. All the rods are distinctly capsuled, and many of them are not stained evenly, showing 1—2 or, in the larger individuals, as many as 5—6 colourless vacuoles.

Young cultures on agar (24 hours at 25° C.) show very similar characters to those described above (Fig. 4) with the exception of the two abnormal forms just mentioned. The size of the rods is very variable, some are almost spherical, the limits of size being ·5—3 μ × ·45—·7 μ;

Fig. 4.

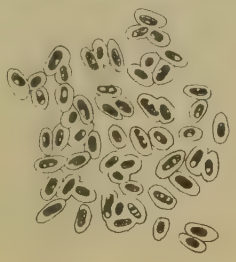

Fig. 5.

Fig. 6.

Fig. 7.

Figures 4–7. *Bacterium nectarophilum*; magnification same as Fig. 1. Fig. 4. 24 hrs. at 25° C. on nutrient agar. Fig. 5. Uschinsky's solution, 7 days at 25° C. Fig. 6. Direct from host plant. Fig. 7. 24 hrs. at 25° C., Ellis's flagella stain.

the majority are 1—1·5 × ·6—·65 μ. They are usually single or in pairs but chains of 5—10 are fairly frequent, and these are peculiar in that the rods are not as a rule placed uniformly end to end, but are

quite as frequently obliquely, or are attached almost laterally (Fig. 4). One or two vacuoles, the contents of which do not stain with carbol fuchsin, can be seen in many individuals; that these non-staining areas are not due to plasmolysis is proved by the fact that they can be clearly seen in the living condition with the dark ground illumination, by which means also the capsule is plainly visible. The capsule stains readily with carbol fuchsin or gentian violet, and is very obvious around rods from the condensation water in tubes containing nutrient agar cultures about four days old. The growth in the condensation water is very viscid, in consistency almost like egg albumen; short rods and almost coccus-like forms predominate. These stain intensively with carbol fuchsin, are surrounded by a colourless capsule and are embedded in a slimy matrix which stains faintly.

After four weeks at 25° C. on nutrient agar only a small percentage of the rods stain intensely, the staining of the majority being very faint and uneven.

In broth cultures the prevailing forms are slightly longer than those on agar, rods 2—2·5μ long being frequent; the vacuolation is distinct.

Very characteristic rods are found in Uschinsky's solution (Fig. 5). Capsuled bacteria form a pellicle on the surface of the fluid; this sinks when disturbed and forms a sediment. The capsule is very conspicuously developed, and the growth is viscid in character like that described in the condensation water at the base of agar streaks; each rod has one, two or more distinct vacuoles.

The organism is actively motile in young cultures (less so as it diffuses out from the tissues of the host) by means of 1—5 polar flagella; these are two to three times the length of the rod, and are occasionally bi-polar but most frequently they are only at one pole. The flagella stain quite readily by Ellis's modification of Loffler's method (Fig. 7).

Staining reactions.

Carbol fuchsin is undoubtedly the best stain for this organism, although it stains well with all the usual stains. It does not stain by Gram's method, and is not acid fast.

Cultural characters.

Nutrient agar (+15). Colonies are visible after 24 hours at 25° C. as thin milky-white growths 1—3 mm. in diameter and rather irregular in shape; after 48 hours, surface colonies are 1—2 cm. diameter, in thinly sown plates, spreading, sub-circular to irregular in shape, the edges

being auriculate-lacerate; they are coppery by transmitted light, creamy white to light dull green yellow[1] by reflected light. In crowded plates the colonies are small and somewhat raised; submerged colonies are very small and are lenticular in outline. A greenish fluorescence may always be observed from agar media on which this organism has been grown; frequently this is very marked, and in thickly sown plates can be detected after 24 hours' growth. This characteristic appears to vary with the composition of the medium, and the conditions under which the organism is grown; it is more marked when the organism has been in cultivation for some time than when it is newly isolated, and also appears to be more conspicuous in cultures which have been exposed to the light; slight variations in the composition of the medium are also probably responsible in some degree for variations of this kind. No crystals have been seen in old cultures. Under the microscope the texture of the surface colonies is homogeneous and very finely granular.

Nutrient agar (+ 15). Streak cultures on nutrient agar are wet-shining, yellowish white, flat smooth, undulate at the edges, and inclined to spread over the wetter parts of the medium. No crystals are formed. There is always more or less fluorescence from the agar, but, as observed in connection with the plate cultures, it is variable. Sometimes there is a distinct greenish fluorescence from the agar and the bacterial growth at the end of 24 hours; sometimes it is not marked until the culture is five or six days old; it is more noticeable when the tubes have been exposed to the light. The growth in the condensation water is very viscid.

Nutrient agar. Stab. The best growth takes place at the top.

Dextrose agar. Streaks were also made on nutrient agar to which 2 % dextrose had been added. On this medium the growth was slightly heavier than on ordinary nutrient agar; it was opaque, creamy white, and the medium was rendered opaque, in contrast to ordinary nutrient agar which remains translucent and exhibits a greenish fluorescence.

Hiss glucose medium produced a very similar growth to that on dextrose agar, but it was more noticeably viscid, drawing out into fine threads on the platinum needle.

Nutrient agar + 2 % dextrose and litmus. The streak is similar in character to that described on nutrient agar with dextrose, but striking colour changes may be observed in the medium. On the

[1] Colours are named according to Ridgway's *Colour Standards and Nomenclature* and have been carefully compared with colour charts in that publication.

sixth day the agar, which was a neutral litmus tint when planted with the organism, is Killarney green, when viewed by transmitted light facing the streak; viewed by transmitted light facing the side of the slant the colour is deep red, nearest Nopal red. By reflected light the upper part of the agar is still green, but from the deeper layers there is a distinctly purplish light reflected. There was no further change in colour during the six weeks the tubes were kept under observation.

Loffler's blood serum is not liquefied, a streak culture on this medium is similar to that on nutrient agar.

Cabbage agar. On this medium the organism forms a ribbon-like streak, honey yellow, 3—4 mm. broad, and with a wrinkled shagreen surface.

Nutrient gelatine (+ 15). Colonies at 20° C. attain a diameter of about 4 mm. in three days; they are thin, spreading, with a slightly irregular margin, in the centre of each colony there is a small, glistening, raised point; the remainder of the growth has a dull, ground glass appearance. Submerged colonies are small, yellowish opaque.

There is no liquefaction, and colonies do not change further, except to increase in size in thinly sown plates. There is no fluorescence in this medium.

Nutrient gelatine stab. There is a growth similar to the gelatine colonies, covering the surface of the medium and a filamentous growth along the upper part of the medium; but no liquefaction during two months and no development in the depths of the medium.

Nutrient gelatine streak is flat, about 4 mm. broad with undulate or crenate margin; here also the growth is dull and thin, and has the appearance of ground glass when held up to the light.

Nutrient bouillon (+ 15) is heavily clouded in 24 hours at 20° C., and afterwards becomes very turbid. There is a tendency to pellicle formation, but when disturbed the pellicle breaks up into flocculi and sinks. A greenish fluorescence may be observed, and is usually very noticeable especially from the surface of the medium. A considerable amount of rather viscid sediment collects at the bottom of the tube or flask.

Nutrient bouillon + 2 % dextrose. The growth in this medium is heavier than in nutrient broth to which no sugar had been added, but the broth does not become fluorescent.

Nitrate bouillon becomes heavily clouded, and there is a thick pellicle, but the fluorescence is not marked.

Dunham's solution is not a very favourable medium and does not

become very densely clouded; a slightly heavier growth was observed in peptone water to which potassium nitrate had been added.

Nutrient bouillon over chloroform; growth was unrestrained in the presence of chloroform; the tubes were clouded in 24 hours, turbid in 48 hours.

Litmus milk is slowly peptonised. After 24 hours at 25° C., the fluid is clear to a depth of about 2 mm. from the surface, the remainder of the milk being unchanged. After 5—6 days the upper third of the medium is clear and translucent, the middle third is partially peptonised, and the remainder still opaque and unchanged; the medium thus exhibits three strata of approximately equal depth. In 8—10 days the whole of the milk has been peptonised, the colour is at first unchanged by reflected light and reddish by transmitted light, but it finally becomes slowly reduced from the top downwards leaving a yellowish translucent fluid. There is a small amount of sediment.

Egg albumen. A medium composed of 1 grm. powdered egg albumen in 50 c.c. of ·05 % potassium phosphate was used to determine the proteolytic activity of the organism. The medium after sterilisation is a colourless liquid in which the insoluble part of the egg albumen has been separated out in white flakes; when planted with the organism the liquid became clouded and then became deep sea foam green in colour. The solid albumen was acted upon and became slimy and soft in consistency.

Uschinsky's solution is clouded in 24 hours at 25° C., after six days it is very turbid, first the upper part of the broth, and gradually the whole of it becoming light, dull, green yellow to clear, dull, green yellow, the colour being much more noticeable by reflected than by transmitted light. There is a fair amount of sediment and the rods are normal and active. There is a ring above the medium, and a pellicle which sinks if the tube is shaken.

At the end of 20 days the pellicle still continues to form, and to sink when disturbed. A very heavy deposit is thus formed which is very viscid and almost like egg albumen in consistency. After some weeks the liquid becomes clear but yellowish; there is some yellowish growth clinging to the sides of the tube and a deposit 1—2 cm. deep in the bottom.

The organism also grows, but less vigorously, in a solution from which the asparagin and ammonium lactate have been omitted and replaced by ammonium sulphate. The organism is therefore able to obtain its nitrogen from a simple salt.

Cohn's solution. No growth.

Potato. A creamy-white, wet-shining streak about 6—8 mm. broad appears along the needle track; the edges are undulate.

Turnip. On turnip there is a thin, wet-looking, whitish growth, almost covering the slant surface.

Beet. On beet the growth is heavier than on turnip and carrot but it is not so spreading; it is yellowish and slightly raised.

Carrot. There is a very thin, whitish, wet-looking growth, in some tubes almost completely covering the slant surface; in others where the cylinder was drier only producing a streak a few millimetres wide along the needle track.

Parsnip. On parsnip there is a good growth along the needle track, 5—10 mm. wide, and slightly raised, shining.

Physical and Biochemical Relations.

Proteolytic activity. It has been pointed out in the section dealing with the cultural characters of the organism that milk is slowly peptonised. If a ten days old culture of the organism is killed by exposing it to a temperature of about 55° C. for half an hour and then 3—5 c.c. of the culture run into each of a number of tubes of sterile litmus milk, it is found that the milk is slowly cleared in precisely the same way as if the organism were growing in the medium.

A series of flask cultivations was carried out with a view to testing for the products of proteolysis. The media used were ordinary nutrient broth, egg albumen (1 gm. in 50 c.c. of ·05 % potassium phosphate) and milk; in each case 50 c.c. of the medium being sterilised in an Erlenmeyer flask of about 150 c.c. capacity. In this way the organism received abundant aeration and growth was fairly rapid.

Cultures in nutrient broth were tested for ammonia by distillation after five days at 25° C. The Nessler test could not be used owing to the presence of an appreciable amount of ammonia in the control flask.

A quantitative test showed that the amount of ammonia in the culture had not increased from the fifth to the tenth day, the difference in each case between the amount of ammonia in the culture flask and the control being ·016 grm. of ammonia nitrogen.

Egg albumen after five days at 25° C. gave a definite reaction for peptone and for tryptophane. The culture was tested by Sorensen's method for amino-acids and ammonia together at the end of the fifth and the tenth day. After five days the result was ·0148 grm. nitrogen

in the form of amino-acids and ammonia: if egg albumen contains ·150 grm. (approximately) total nitrogen, then 2·8 % of the total nitrogen had been broken down; after 10 days the figures were ·007 grm. or approximately 4·6 % of the total nitrogen.

Milk cultures after ten days tested by the Sorensen method contained ·019—·022 grms. nitrogen in the form of amino-acid and ammonia. When tested by distillation for ammonia alone, practically the same figures were obtained; it was evident therefore that the amino-acids had been reduced to ammonia.

Tested qualitatively the milk culture gave a very decided reaction for peptone and for tyrosin.

The results recorded above are sufficient evidence that the organism is a fairly active proteolytic agent.

Amylolytic action. Potato cylinders on which the organism has been growing for any length of time give the red-brown reaction for amylodextrin when treated with Lugol's iodine solution rather than the deep blue starch reaction.

Tubes containing 10 c.c. nutrient bouillon and ·01 grm. soluble starch were planted with a vigorous culture and incubated at 25° C. It was between two and three weeks before the starch totally disappeared. The action of the organism on starch therefore is comparatively slow.

Invertase and *lactase* are not produced by this organism. This is shown by the fact that although the organism produces acid in solutions containing dextrose and galactose it is unable to do so in those containing lactose and saccharose. Were it capable of reducing these sugars, acid would be formed in solutions containing them.

Fermentation reactions. No gas was produced in fermentation tubes containing peptone water tinted with litmus and 2 % of various carbohydrates. The amount of growth and presence or absence of acid production may be scheduled as follows:

Carbohydrate	Acid production	Nature of growth
Dextrose	Distinctly acid after 3 days	Moderate
Dextrin	None	Very heavy
Galactose	Distinctly acid after 3 days	Moderate
Glycerine	None	Light clouding
Laevulose	,,	,, ,,
Lactose	,,	,, ,,
Maltose	,,	,, ,,
Mannite	,,	,, ,,
Saccharose	,,	,, ,,
Starch	,,	,, ,,

A quantitative test for acid production was carried out with some of the sugars mentioned above. Cultivations were prepared in bulk in flasks containing 50 c.c. nutrient broth and 2 % of the substances to be tested. They were incubated for 10 days at 20° C. and were as follows (expressed in degrees of Fuller's scale).

Sugar	Culture	Control
Dextrose	+35·5	+15·6
Glycerine	+10	+15
Lactose	0	+15
Laevulose	+10	+15
Saccharose	0	+15

It will be observed that except in the case of dextrose the culture was slightly less acid than the control.

No reaction for alcohol or aldehyde was obtained in the distillate from a culture in dextrose bouillon.

Indol. There was no indol in cultures in Dunham's solution or in nutrient bouillon after 10—12 days at 20° C. Tests for phenol were also negative.

Pigment production. It has already been pointed out in the section on the cultural characters of the organism that it produces on certain media a distinct greenish or greenish yellow fluorescence.

Colour destruction. Methylene blue was almost completely reduced in 24 hours; neutral red and rosolic acid were not reduced. Litmus was partially reduced in milk cultures but not in nutrient broth.

Nitrate reduction. Nitrates were not reduced to nitrites during ten days growth in nitrate broth and in nitrate peptone water at 25° C.

Gas production. It has been stated that no gas is produced in fermentation tubes containing various sugar solutions.

Cultivations were prepared in iron and lead peptone solution; the precipitate began to blacken after some days, that in the tubes to which iron tartrate had been added becoming decidedly black, thus showing that some sulphuretted hydrogen had been liberated.

Growth under anaerobic conditions. The organism grows very slowly in glucose formate agar in Bulloch's apparatus from which the oxygen has been absorbed. Control tubes under ordinary atmospheric conditions made a very vigorous growth.

Temperature. The optimum temperature for growth lies between 25 and 30° C. The organism grows much more slowly at 20 than at 25° C. and at 35 than at 30° C.

The thermal death point is 49° C., ten minutes exposure in thin walled test tubes containing 10 c.c. nutrient broth.

Reaction of medium. The bacterium is not specially sensitive to the reaction of the medium in which it is grown. The optimum reaction lies between + 10 and + 20 Fuller, + 15 taken as approximately the optimum for cultural purposes.

The following table will serve to indicate the extreme reactions at which growth will take place and the amount of various substances necessary to inhibit growth.

Acid or alkali	Amount to restrain growth	Amount to inhibit growth
Acetic acid	+20	+25
Citric acid	+45	+50
Hydrochloric acid	+18	+20
Malic acid	+68	+70
Oxalic acid	+35	+40
Tartaric acid	+30	+35
Sodium hydrate	+30	+55

Toleration of sodium chloride. Cultivations were made in nutrient bouillon to which varying amounts of NaCl had been added. Growth was unrestrained in tubes containing up to 4 % NaCl, meagre in those with 5 to 6 % and inhibited in those with 7 %.

Desiccation. The organism is not particularly sensitive to desiccation; cultures are readily obtained from cover slips on which the organism has been dried for six weeks; more prolonged tests have yet to be made.

Insolation. The bacterium is fairly sensitive to the action of direct sunlight. Five minutes exposure is sufficient to destroy a large percentage of the rods and ten minutes to kill them all. The exposures were made on a block of ice, to the mid-day summer sun, the plates being further protected by being covered with glass basins containing about 2 cm. of a 4 % solution of potash alum.

The growth of the organism is not restrained in the diffuse light of the laboratory.

Nomenclature.

The organism appears to be one which has not previously been described. I therefore propose for it the name *Bacterium nectarophilum* n.sp., its chief characters are as follows:

Bacterium nectarophilum n.sp., parasitic in pear blossoms, causing blackening of the receptacle and ovary, and less frequently of the sepals and flower stalks; a short rod ·5—3μ × ·45—·7μ, majority are 1—1·5μ × ·6—·65μ; rods single or in pairs, short chains are fairly frequent,

capsule always present, motile by means of 1—5 polar flagella. Gram-negative.

Forms spreading yellowish-white colonies in nutrient agar, fluorescent; fluorescence absent in media containing dextrose; gelatine is not liquefied; nutrient bouillon heavily clouded; milk slowly peptonised, no change in reaction. Uschinsky's solution clouded, fluorescent, growth viscid; potato growth moderate.

Fairly active proteolytic agent; starch slowly destroyed; acid from dextrose and galactose, no gas or acid from any of the other carbohydrates tested; no indol; nitrates not reduced.

Facultative anaerobe; optimum temperature 25—30° C.; T.D.P. 49° C.

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A LIST OF COCCIDAE AFFECTING VARIOUS GENERA OF PLANTS.

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For several years I have been collecting records of the Coccidae that infest different genera of plants, extracted—partly from my own collections and observations, and partly from existing publications and periodical literature. Mrs Fernald's *Catalogue of the Coccidae of the World* has, naturally, provided the foundation for such an undertaking, and Lindinger's *Die Schildlause* has afforded many additional records, as have also the supplementary catalogues issued by the U.S. Bureau of Entomology. Other papers that have been laid under contribution are too numerous to mention.

The names are entered just as they are published. The compiler does not hold himself responsible for the accuracy of the determinations.

I have found this list so useful, and such a time-saving device in my own work, that I propose to publish it, in parts, in the hope that it may prove equally useful to others engaged in similar work. When a Coccid is sent in for determination, a reference to my list immediately shows what species of that particular genus have been recorded from the plant in question. It is surprising how often this has provided a clue to the identity of the species under consideration. The list, it must be acknowledged, is far from complete and—from its nature—must remain so. Fresh records will be constantly occurring, necessitating further additions. But, with this as a foundation, it should not be difficult for individual students to keep the list up to date for themselves.

I have not attempted to keep records for individual species of plants. Nor do I consider that such an amplification of detail would repay the labour entailed. As a matter of fact, it will be found that few species of Coccidae are restricted to a single species of plant, though many of them have a distinct preference for particular genera. A list of the Coccidae found in the nests of, or associated with ants, is included.

With regard to nomenclature, I have—in the main—followed Mrs Fernald's *Catalogue*; but I have found it convenient to retain—in their broader application—such genera as *Lecanium*, *Aspidiotus*, *Chionaspis*, *Diaspis*, etc.

ABIES (Coniferae).
- Phenacoccus piceae.
- Physokermes coloradensis, concolor, piceae, sericeus.
- Lecanium sericeum.
- Chionaspis pinifoliae.
- Poliaspis pini.
- Leucaspis kelloggi.
- Aspidiotus perniciosus, ehrhorni, meyeri, abietis, ostreaeformis, tsugae, littleri.
- Lepidosaphes abietis, ulmi-japonica.

ABUTILON (Malvaceae).
- Ceroplastes novaesi.
- Lecanium hesperidum, minimum, oleae-mirandum, nigrum, oleae, hesperidum-alienum.
- Aspidiotus rossi.

ACACIA (Leguminosae).
- Lophococcus vuilleti.
- Llaveia mexicanorum.
- Monophlebus herculus.
- Aspidoproctus armatus, mirabilis, tricornis.
- Icerya koebelei, natalensis, purchasi, longisetosa.
- Callipappus immanis.
- Asterolecanium hakeae, ventruosum, variolosum.
- Lecaniodiaspis acaciae, africana, anomala.
- Rhizococcus grandis, grandis-spinosior, viridis, lobulatus, bicolor, lidgetti.
- Eriococcus multispinosus-laevigatus.
- Kermes acaciae.
- Sphaerococcus acaciae, obscuratus.
- Epicoccus acaciae.
- Phenacoccus nivalis, farnesianae.
- Lachnodius hirtus.
- Pseudococcus longispinus, acaciae, albizziae, farnesianae, lanigerus, robiniae, texensis, coccineus, perniciosus, iceryoides, filamentosus, solitarius, quaesitus, nitidus, globosus, swezeyi, candidus, hilli.
- Tachardia acaciae, nigra, aurantiaca, argentina, lacca.
- Pulvinaria paradelpha, tecta.
- Ceroplastes africanus, egbarum, africanus-senegalensis.
- Ceroplastodes acaciae.
- Inglisia fossilis, vitrea.
- Ctenochiton serratus, transparens.
- Lecanium longulum, robiniarum, oleae, cadaverosum, leve, scrobiculatum, mirificum.
- Cryptes baccatus.
- Protodiaspis anomala.
- Diaspis boisduvallii.
- Chionaspis capensis.
- Hemichionaspis aspidistrae.
- Cryptohemichionaspis nigra.
- Fiorinia acaciae, rubra, rubra-propinqua.
- Aspidiotus caldesii, ceratus, fodiens, hederae, niveus, perniciosus, camelliae, rossi, unilobis, dentilobis, acaciae, gidgei, subfervens, serratus, africanus, junctiloba, tasmaniae, conspiciendus, aurantii, dictyospermi, lataniae, quadriareolata, bipartitus, phenox.
- Aonidia glandulosa.
- Gymnaspis acaciae.
- Lepidosaphes acaciae, acaciae-albida, convexa, grisea, spinifera, corticoides, wilgae, multipora, chitinosa, recurvata, intermedia, somalensis.

ACALYPHA (Euphorbiaceae).
- Pseudococcus virgatus.
- Pulvinaria floccifera.
- Pseudoparlatoria ostreata.

ACER (Aceraceae) 'Sycamore,' 'Maple,' etc.
- Palaeococcus fuscipennis.
- Eriococcus aceris.

ACER (Aceraceae)—*cont.*
PHENACOCCUS acericola, aceris.
PSEUDOCOCCUS comstocki.
PULVINARIA acericola, horii, hunteri, innumerabilis.
LECANIUM aceris, canadense, cerasifex, crawi, nigrofasciatum, rugosum, tiliae, websteri-mirabile, corni.
CHIONASPIS platani, salicis.
HEMICHIONASPIS aspidistrae.
LEUCASPIS japonica.
ASPIDIOTUS abietis, ancylus, comstocki, fernaldi-albiventer, forbesi, hederae, juglans-regiae, ostreaeformis, perniciosus, camelliae, tenebricosus.
PARLATORIA pergandei, theae.

ADENOSTOMA (Rosaceae).
LECANIODIASPIS rufescens.
ERIOCOCCUS adenostomae.
LECANIUM adenostomae.

ADIANTUM (Filices) 'Maidenhair Fern.'
PSEUDOCOCCUS longispinus.
RIPERSIA glandulifera.
LECANIUM hesperidum, hemisphaericum, oleae.
PULVINARIA floccifera.
CHIONASPIS dubia.

AESCULUS (Hippocastanaceae) 'Horse-chestnut.'
CEROCOCCUS parrotti.
PHENACOCCUS aceriola, hystrix, aceris.
PULVINARIA horii, innumerabilis.
LECANIUM aesculi, coryli.
ASPIDIOTUS aesculi, ostreaeformis, ohioensis, perniciosus.
LEPIDOSAPHES ulmi.
DIASPIS pentagona.

AGAVE (Amaryllidaceae).
GYMNOCOCCUS agavium.
PSEUDOCOCCUS ephedrae.
CEROPLASTES ceriferus.
LECANIUM oleae, nigrum.
HEMICHIONASPIS minor.
ASPIDIOTUS hederae, agavis, aurantii, bowreyi, dictyospermi, ficus, lataniae.
LEPIDOSAPHES nigra, philococcus.
OPUNTIASPIS javanensis.

AGLAIA (Meliaceae).
PSEUDOPARLATORIA argentata.
ASPIDIOTUS gracilis.
AONIDIA viridis.
LEPIDOSAPHES travancoriensis.

AGONIS (Myrtaceae).
ERIOCOCCUS agonis.
SPHAEROCOCCUS rugosus.
CHIONASPIS agonis.

AGROPYRON (Gramineae).
PSEUDOCOCCUS pulverarius.
TRIONYMUS perrisii, violascens.
PARAFAIRMAIRIA bipartita.
ACLERDA subterranea.
ERIOPELTIS festucae.
ANTONINA purpurea.

AGROSTIS (Gramineae).
ERIOCOCCUS insignis.
PSEUDOCOCCUS walkeri, pulverarius.
RIPERSIA corynephori.
ERIOPELTIS festucae.

AILANTHUS (Simarabaceae).
DIASPIS rosae, pentagona.
LEPIDOSAPHES ulmi.

ALBIZZIAE (Leguminosae).
PSEUDOCOCCUS albizziae, perniciosus, capensis, filamentosus, longispinus.
LECANIUM longulum, elongatum.
CEROPLASTES subsphaericus.
TACHARDIA albizziae, lacca.
HEMICHIONASPIS minor.
ASPIDIOTUS hederae.

ALLAMANDA (Apocynaceae).
CEROPUTO barberi.
LECANIUM mangiferae.

ALNUS (Betulaceae) 'Alder.'
GOSSYPARIA spurius.
PHENACOCCUS farinosus, aceris.
PULVINARIA betulae-alni, ehrhorni, innumerabilis, goethei, occidentalis, innumerabilis-betheli, vitis.
LECANIUM alni, corni, coryli.
CHIONASPIS lintneri, salicis, wistariae.
ASPIDIOTUS ostreaeformis, perniciosus, alni.
LEPIDOSAPHES ulmi.

ALOCASIA (Araceae).
- Pseudococcus longipes.
- Pinnaspis buxi.
- Hemichionaspis aspidistrae.
- Aspidiotus destructor.

ALOE (Liliaceae).
- Chionaspis exalbida.
- Aspidiotus hederae, cladii, dictyospermi, mammillaris.

ALSTONIA (Apocynaceae).
- Lecanium viride, oleae.
- Vinsonia stellifera.
- Lepidosaphes alstoniae.

AMELANCHIER (Rosaceae).
- Phenacoccus cockerelli, betheli.
- Lecanium kansasense.
- Chionaspis lintneri, salicis-nigrae.
- Aspidiotus fernaldi-albiventer, perniciosus.
- Lepidosaphes ulmi.

AMMOPHILA (Gramineae).
- Pseudococcus hibernicus.
- Aspidiotus provincialis.

AMPELOPSIS (Vitaceae).
- Lecanium magnoliarum, nigrum.
- Aspidiotus perniciosus, tasmaniae.

AMYGDALUS (Rosaceae) 'Peach,' 'Almond,' etc.
- Asterolecanium pustulans.
- Phenacoccus aceris.
- Pulvinaria amygdali.
- Lecanium armeniacum, canadense, cerasifex, cockerelli, persicae, pruinosum, prunastri, rugosum, hemisphaericum, nigrofasciatum.
- Epidiaspis piricola.
- Chionaspis furfura.
- Diaspis leperii, pentagona.
- Aspidiotus ancylus, forbesi, juglansregiae, ostreaeformis, perniciosus, camelliae, africanus, cyanophylli.
- Pseudoparlatoria parlatorioides.
- Parlatoria calianthina, proteus.

ANACARDIUM (Anacardiaceae).
- Ceroplastes floridensis.
- Aspidiotus personatus, sylvaticus, replicatus.

ANANASSA (Bromeliaceae) 'Pine-apple.'
- Pseudococcus bromeliae, ananassae, citri.
- Diaspis bromeliae, boisduvallii.
- Aspidiotus bromeliae.
- Pseudischnaspis bromeliae.

ANDROMEDA (Ericaceae).
- Ceroplastes floridensis.
- Chionaspis salicis.

ANDROPOGON (Gramineae).
- Eriococcus kemptoni.
- Aclerda californica, obscura.
- Lecanium tenuivalvatum.
- Chionaspis graminis.
- Aspidiotus marlatti.

ANGRAECUM (Orchidaceae).
- Conchaspis angraeci.
- Asterolecanium aureum, epidendri.

ANONA (Anonaceae) 'Custard-apple,' Sour-sop,' etc.
- Icerya albolutea.
- Asterolecanium pustulans.
- Tachardia lacca, decorella.
- Pseudococcus citri, capensis.
- Stictococcus dimorphus, diversiseta.
- Ceroplastes denudatus, floridensis, quadrilineatus, ugandae, rusci.
- Inglisia conchiformis.
- Lichtensia crescentiae.
- Lagosinia strachani.
- Lecanium longulum, marsupiale, hemisphaericum, nigrum, viride.
- Howardia biclavis.
- Diaspis miranda.
- Aspidiotus cyanophylli, destructor, translucens, gowdeyi.

ANTHURIUM (Araceae).
- Asterolecanium aureum.
- Ceroplastes floridensis.
- Lecanium angustatum, anthurii, nigrum, hesperidum.

ANTIDESMA (Euphorbiaceae).
- Kuwania zeylanica.
- Lecanium antidesmae, oleae, planum.
- Chionaspis flava, acuminata.
- Dinaspis permutans.
- Aspidiotus rossi.

ANTIGONON (Polygonaceae).
- Ceroplastes ceriferus.
- Pulvinaria antigoni.
- Lecanium hemisphaericum.

ANTS' NESTS.
Stigmacoccus asper, ferox.
Icerya formicarum.
Orthezia lasiorum, occidentalis, cataphracta, floccosa, olivacea.
Ortheziola vejdovskyi.
Anomalococcus cremastogastri.
Rhizococcus texanus.
Eriococcus apiomorphae.
Ceroputo lasiorum.
Natalensia fulleri.
Tylococcus madagascariensis.
Micrococcus silvestrii, oviformis.
Phenacoccus americanae, glacialis, ripersioides, hirsutus, formicarum.
Pseudococcus claviger, cockerelli, formiceticola, hirsutus, neomexicanus-indecisus, sorghiellus, myrmecarius, sorghiellus-kingi, wheeleri, cycliger, flagrans.
Ripersia arizonensis, aurantia, blanchardi, cockerellae, confusella, europaea, fimbriatula, flaveola, formicicola, kingi, lasii, minima, montana, subterranea, tomlini, trivittata, tumida, globata, viridula, wasmanni, donisthorpei, formicarii, inquilina, sardiniae, trichura.
Ripersiella leucosoma.
Termitococcus aster, brevicornis.
Stictococcus formicarii.
Exaeretopus formiceticola.
Lecanium formicarii, urichi, discrepans.
Lecanopsis formicarum, lineolata, myrmecophila.
Houardia troglodytes.
APOLLONIAS (Lauraceae).
Lecanium hesperidum.
Cryptaspidiotus aonidioides, barbusano.
Aspidiotus lauretorum, dictyospermi, camelliae.
Aonidia lauri.
Fiorinia pellucida.
'APPLE'
Pseudococcus bakeri.
Pulvinaria amygdali, innumerabilis.
Lecanium hoferi, bituberculatum, cerasifex, pyri, variegatum, oleae, glandi.
Chionaspis furfura.
Diaspis pyri.
Epidiaspis pyricola.
Aspidiotus ancylus, forbesi, juglans-regiae, ostreaeformis, perniciosus, pyri, camelliae, aurantii, africanus, tenebricosus, lataniae.
Parlatoria calianthina, proteus, de structor, chinensis, pyri.
Leucaspis japonica.
Lepidosaphes ulmi.
'APRICOT.'
Lecanium armeniacum, oleae.
Diaspis pentagona.
Aspidiotus forbesi, juglans-regiae, perniciosus, africanus.
ARALIA (Araliaceae).
Pulvinaria innumerabilis, floccifera, psidii.
Lecanium persicae, hesperidum, oleae, nigrum, persicae-crudum.
Diaspis pentagona.
Aspidiotus ficus, dictyospermi.
ARAUCARIA (Coniferae).
Eriococcus araucariae, angulatus.
Pseudococcus aurilanatus, ryani, adonidum.
Ctenochiton araucariae.
Aspidiotus rossi.
Parlatoria pergandei.
ARBUTUS (Ericaceae).
Lecanium coryli, corni.
Aspidiotus hederae, vitis-arbutus, dictyospermi.
ARCTOSTAPHYLUS (Ericaceae).
Eriococcus uvae-ursi.
Pulvinaria ericae.
Diaspis manzanitae.
Aspidiotus dearnessi, arctostaphyli.
Chionaspis salicis.
Lepidosaphes ulmi.
ARDISIA (Myrsinaceae).
Nipponorthezia ardisiae.
Lecanium hemisphaericum, tessellatum.
Chionaspis acuminata.

ARECA (Palmae).
- Pseudococcus arecae.
- Lecanium minimum, hemisphaericum, acutissimum.
- Hemichionaspis aspidistrae, dracaenae.
- Diaspis boisduvallii.
- Pinnaspis buxi.
- Aspidiotus lataniae, dictyospermi, personatus.
- Fiorinia fioriniae.

ARISTOLOCHIA (Aristolochiaceae).
- Icerya aegyptiaca.
- Pseudococcus longispinus.
- Aspidiotus lataniae.

ARMERIA (Plumbagineae).
- Pseudococcus hibernicus.
- Ripersia halophila.

ARTEMISIA (Compositae).
- Orthezia artemisiae, urticae.
- Eriococcus artemisiae, catalinae.
- Phenacoccus artemisiae.
- Pseudococcus artemisiae.
- Erium lichtensioides.
- Pulvinaria artemisiae.
- Ceroplastes rusci.
- Aspidiotus rossi.

ARTOCARPUS (Urticaceae).
- Monophlebus octocaudata.
- Icerya aegyptiaca.
- Pseudococcus corymbatus.
- Lecanium mangiferae, psidii.
- Chionaspis subcorticalis.
- Aspidiotus longispinus, artocarpi, hederae, lataniae, trilobitiformis.
- Fiorinia fioriniae.

ARUNDINARIA (Gramineae).
- Asterolecanium lanceolatum, solenophoroides.
- Antonina socialis.
- Aclerda distorta, japonica.
- Lecanium arundinariae.
- Chionaspis arundinariae, elongata.
- Odonaspis secreta.

ARUNDO (Gramineae).
- Aclerda berlesii.
- Chionaspis berlesii.

ASPARAGUS (Liliaceae).
- Pseudococcus longispinus, virgatus.
- Lecanium anthurii, hemisphaericum, nigrum, oleae.
- Filippia ephedrae.
- Chionaspis berlesii.
- Aspidiotus hederae, cydoniae, camelliae.

ASPIDISTRA (Liliaceae).
- Hemichionaspis aspidistrae.
- Aspidiotus ficus.

ASPLENIUM (Filices).
- Lecanium hesperidum, mori, oleae.
- Hemichionaspis aspidistrae.
- Chionaspis dubia.

ASTELIA (Liliaceae).
- Phenacoccus asteliae.
- Pseudococcus montanus.
- Leucaspis gigas, stricta.
- Lepidosaphes cordylinidis, epiphytidis, pryiformis.

ASTER (Compositae).
- Orthezia urticae.
- Eriococcus eucalypti.
- Tachardia australis.
- Lecanium oleae.

ATALANTIA (Rutaceae).
- Aspidiotus ficus.
- Parlatoria atalantiae.
- Fiorinia atalantiae.

ATHEROSPERMA (Atherospermaceae).
- Lecaniodiaspis atherospermae.
- Eriochiton spinosus.
- Ctenochiton viridis.
- Chionaspis eugeniae.
- Leucaspis gigas.
- Aspidiotus atherospermae.
- Lepidosaphes pyriformis.

ATRIPLEX (Chenopodiaceae).
- Orthezia annae, varipes.
- Cerococcus coloradensis.
- Atriplicia gallicola.
- Eriococcus neglectus, tinsleyi, parcispinosus.
- Phenacoccus simplex.
- Pseudococcus solani-atriplicis.
- Pulvinaria maskelli.
- Ceroplastes irregularis, breviseta.
- Luzulaspis spinulosa.
- Lepidosaphes concolor, concolor-viridissima, alba, alba-concolor.

ATYLOSIA (Leguminosae).
Ceroplastodes cajani.
Aspidiotus orientalis.
AUCUBA (Cornaceae).
Chionaspis aucubae.
Aspidiotus hederae, dictyospermi, aurantii-citrinus.
AVERRHOA (Oxalidaceae).
Lecanium longulum.
Inglisia conchiformis.
AZALEA (Ericaceae).
Eriococcus azaleae.
Pseudococcus azaleae.
Phenacoccus azaleae.
Aspidiotus duplex, paeoniae.

BACCHARIS (Compositae).
Cerococcus baccharidis, tuberculus, badius.
Eriococcus armatus, brasiliensis.
Ceroplastes albolineatus, grandis, iheringi, lucidus, novaesi.
Alichtensia attenuata.
Pulvinaria pulchella.
Lecanium baccharidis, dura, resinatum.
Diaspis baccharidis.
Lepidosaphes perlonga.
BACTRIS (Palmae).
Asterolecanium urichi.
Diaspis boisduvallii.
BAHIA (Compositae).
Palaeococcus townsendi.
Orthezia californica.
Ceroputo bahiae.
Eriococcus bahiae.
BAMBUSA (Gramineae).
Asterolecanium bambusae, delicatum, miliaris, miliaris-longum, miliaris-robusta, solenophoroides, coronatum, lanceolatum, ceriferum, ceriferum-prominens, exiguum, flavociliatum, pudibundum, rubrocomatum, tenuissimum, tumidum, udagamae, bambusicola, masuii.
Eriococcus graminis, onukii.
Pseudococcus takae, monticola, pulverarius-bambusae.
Antonina bambusae, crawi, socialis, zonata.
Pseudantonina bambusae.
Aclerda japonica, distorta.
Lecanium longulum, depressa, nigrum, arundinariae.
Diaspis bambusae.
Chionaspis arundinariae, bambusae, colemanni, howardi, elongata, linearis, gudelura, annandalei.
Pinnaspis bambusae.
Fiorinia bambusae, signata, tenuis.
Leucaspis bambusae.
Odonaspis bambusarum, canaliculata, inusitata, secreta, simplex, penicillata, schizostachys.
Lepidosaphes bambusicola, bambusae.
Ischnaspis filiformis.
Aspidiotus ficus.
Parlatoria zeylanica.
BANKSIA (Proteaceae).
Callipappus bufo.
Asterolecanium variolosum.
Eriococcus eucalypti.
Ceronema banksiae.
Lecanium frenchi, fuciforme.
Aspidiotus subrubescens, rossi.
Aonidia banksiae.
Lepidosaphes banksiae, citricola, fulleri, grandilobis.
BAUHINIA (Leguminosae).
Asterolecanium pustulans.
Lecanium hesperidum.
BEAUMONTIA (Apocynaceae).
Lecanium beaumontiae.
Aspidiotus trilobitiformis.
BEGONIA (Begoniaceae).
Lecanium begoniae, nigrum, hesperidum, signiferum.
Aspidiotus ficus.
BENZOIN (Lauraceae).
Lecanium nigrofasciatum.
Chionaspis lintneri.
BERBERIS (Berberidaceae).
Fonscolombia braggi.
Lecanium magnoliarum, corni, persicae.
Epidiaspis leperei.
Lepidosaphes ulmi.

BETULA (Betulaceae) 'Birch.'
- Xylococcus betulae.
- Steingelia gorodetskia.
- Phenacoccus aceris.
- Pulvinaria vitis, betulae, occidentalis-subalpina.
- Lecanium douglasi, nigrofasciatum, websteri, coryli, ciliatum, zebrinum, transvittatum.
- Chionaspis lintneri-betulae, salicis.
- Aspidiotus ostreaeformis, perniciosus, camelliae.
- Lepidosaphes ulmi.

BEYERIA.
- Apiomorpha beyeriae.
- Tachardia australis.
- Lepidosaphes beyeriae.

BIGELOWIA (Orchidaceae).
- Pulvinaria bigeloviae.
- Aspidiotus bigeloviae, yuccarum.

BIGNONIA (Bignoniaceae).
- Pulvinaria cupaniae, psidii.
- Ceroplastes cistudiformis.
- Lecanium viride.

BIOTA (Coniferae).
- Lecanium arion.
- Diaspis visci.

BOSSIAEA (Leguminosae).
- Pulvinaria contexta.
- Aspidiotus bossieae.

BOUGAINVILLEA (Nyctagineae).
- Orthezia insignis.
- Asterolecanium pustulans-seychellarum.

BRACHYGLOTTIS (Compositae).
- Ctenochiton flavus.
- Fiorinia minima.

BROUSSONETIA (Urticaceae) 'Paper-Mulberry.'
- Lecanium corni.
- Diaspis pentagona.
- Aspidiotus oreodoxae, longispinus, hederae.

BURSARIA (Pittosporaceae).
- Cerococcus auranticus.
- Eriococcus eucalypti, tepperi, bursariae, villosa.

BURSERA (Burseraceae).
- Icerya purchasi.
- Ceroplastes cassiae, dugesii.

BUXUS (Euphorbiaceae) 'Box.'
- Eriococcus buxi.
- Phenacoccus aceris.
- Lecanium hesperidum, corni.
- Pinnaspis buxi.
- Aspidiotus hederae, aurantii, dictyospermi, britannicus, rossi.

CACTUS (Cactaceae).
- Llaveia cacti.
- Dactylopius cacti, confusus, newsteadi, tomentosus, indicus, argentinus.
- Eriococcus coccineus, multispinosus.
- Pseudococcus mamillariae, virgatus.
- Pulvinaria floccifera.
- Diaspis echinocacti.
- Aspidiotus cydoniae.

CAESALPINIA (Leguminosae).
- Tachardia lacca.
- Pseudococcus virgatus.
- Ceronema africana.
- Aspidiotus subsimilis.

CAJANUS (Leguminosae) 'Pigeon-pea.'
- Tachardia lacca.
- Phenacoccus insolitus.
- Stictococcus dimorphus, diversiseta.
- Lecanium elongatum, oleae, cajani.
- Ceronema africana.
- Eriochiton theae.
- Ceroplastes africanus, ugandae.
- Ceroplastodes cajani, chiton.

CALADIUM (Araceae).
- Pseudococcus longispinus.
- Pulvinaria darwiniensis.

CALAMAGROSTIS (Gramineae).
- Trionymus perrisii.
- Eriopeltis lichtensteini.

CALAMUS (Palmaceae).
- Aspidiotus calami.
- Lepidosaphes mexicana.

CALATHEA (Marantaceae).
- Asterolecanium aureum.
- Pseudococcus citri.
- Hemichionaspis aspidistrae.

CALLICARPA (Verbenaceae).
- Mallococcus sinensis.
- Howardia biclavis.
- Diaspis pentagona.

CALLISTEMON (Myrtaceae).
Pseudococcus citri.
Chionaspis candida.
Aspidiotus dictyospermi, rossi.
Aonidia pulchra.

CALLITRIS (Coniferae).
Pulvinaria maskelli-spinosior.
Diaspis visci.
Cryptaspidiotus mediterraneus.
Poliaspis exocarpi.
Chionaspis striata.

CALLUNA (Ericaceae) 'Ling,' 'Heather,' etc.
Orthezia cataphracta.
Eriococcus ericae.
Pseudococcus calluneti.
Lecanium pulchrum, franconicum.
Aspidiotus bavaricus.
Lepidosaphes ulmi.

CALOPHYLLUM (Guttiferae).
Asterolecanium gutta, ceylonicum.
Erioides cuneiformis.
Lecanium bicruciatum, frontalis, calophylli, tessellatum, tripartitum.
Ceroplastes rubens.
Aspidiotus dictyospermi, calophylli.

CALOTROPIS (Asclepiadaceae).
Lecanium oleae.
Aspidiotus orientalis.

CALYCOTOME (Leguminosae).
Lecanium persicae.
Aspidiotus hederae.

CAMELLIA (Ternstromiaceae).
Lecanium hesperidum, depressum-simulans, hemisphaericum, oleae.
Pulvinaria camelicola, floccifera, linearis, vitis.
Ceroplastes ceriferus, floridensis.
Aspidiotus degeneratus, hederae, camelliae, spinosus, ficus, maskelli, clavigera, duplex, paeoniae, dictyospermi.
Parlatoria pergandei-camelliae, proteus, proteus-virescens.
Fiorinia fioriniae.

CAMPANULA (Campanulaceae).
Asterolecanium fimbriatum.
Aspidiotus implicatus.

CAMPHORA (Lauraceae).
Aspidiotus duplex, ficus, aurantii.

CANNA (Marantaceae) 'Indian Shot,' etc.
Pseudococcus bromeliae.
Lecanium nigrum.
Ceroplastes actiniformis, ceriferus.
Diaspis bromeliae.

CAPPARIS (Capparidaceae).
Phenacoccus iceryoides.
Lecanium capparidis.
Hemichionaspis aspidistrae.
Aspidiotus rossi, hederae, niger, pseudocamelliae.

CAPSICUM (Solanaceae).
Orthezia insignis, praelonga.
Icerya purchasi.
Pulvinaria urbicola.
Hemichionaspis minor.

CAREX (Cyperaceae).
Orthezia cataphracta.
Exaeretopus caricis.
Luzulaspis luzulae.
Lecanopsis longicornis.
Parafairmairia gracilis.

CARICA (Cucurbitaceae) 'Papaya.'
Lecanium longulum.
Diaspis pentagona.
Aspidiotus orientalis, destructor.

CARISSA (Apocynaceae).
Cerococcus ornatus.
Lecanium maritimum, oleae, hemisphaericum, longulum.
Chionaspis acuminata-atricolor.
Poliaspis carissae.
Aonidia pusilla.
Aspidiotus rossi, lataniae.

CARPINUS (Corylaceae) 'Hornbeam,' etc.
Phenacoccus acericola, aceris.
Lecanium alni-rufulum, ribis, websteri, coryli, pulchrum.
Pulvinaria carpini, betulae.
Aspidiotus ostreaeformis.
Lepidosaphes ulmi.

CARYA (Juglandaceae) 'Hickory,' 'Pecan,' etc.
Pseudococcus jessica.
Lecaniodiaspis tessellata.
Lecanium canadense, caryae, caryarum, pyri.
Chionaspis caryae.

CARYA (Juglandaceae)—*cont.*
- Aspidiotus perniciosus, uvae, obscurus.

CARYOTA (Palmaceae).
- Lecanium tessellatum, signiferum.

CASSIA (Leguminosae).
- Icerya seychellarum.
- Tachardia lacca.
- Pseudococcus virgatus.
- Lecanium longulum, opimum, tuberculatum.
- Ceroplastes cassiae.
- Ceroplastodes chiton.
- Ctenochiton aztecus.
- Hemichionaspis minor, chionaspiformis.
- Chionaspis cassiae.
- Aspidiotus tesseratus, victoriae, orientalis.

CASSINE (Celastraceae).
- Chionaspis elongata.
- Aspidiotus piceus.

CASTANEA (Corylaceae) 'Spanish Chestnut.'
- Pseudopulvinaria sikkimensis.
- Lecanium armeniacum, quercitronis, takachihoi, pulchrum, nigrofasciatum.
- Aspidiotus perniciosus.
- Lepidosaphes ulmi.

CASTILLOA (Artocarpaceae).
- Pseudococcus virgatus, crotonis.
- Lecanium castilloae.
- Inglisia castilloae.
- Aspidiotus destructor.

CASUARINA (Casuarinaceae).
- Callipappus bufo, farinosus.
- Icerya purchasi.
- Frenchia casuarinae, semiocculta.
- Cylindrococcus casuarinae, gracilis, spiniferus.
- Sphaerococcus casuarinae, ethelae, lesii.
- Ouracoccus casuarinae.
- Gossyparia casuarinae.
- Eriococcus conspersus, cypraeaeformis, elegans.
- Rhizococcus casuarinae, pustulatus, tripartitus, lecanioides, casuarinae-mancus.
- Pseudoripersia turgipes.
- Pseudococcus corymbatus.
- Phenacoccus casuarinae.
- Lecanium innocens.
- Poliaspis casuarinae.
- Fiorinia casuarinae.
- Aspidiotus casuarinae, eucalypti, cingulatus, pauciglandulatus, bidens.
- Aonidia paradoxa.
- Lepidosaphes casuarinae, striata, lobulatus, complicata.

CATALPA (Bignoniaceae).
- Ceroplastes marmoreus, mexicanus.
- Diaspis pentagona.
- Aspidiotus perniciosus, ulmi.

CATTLEYA (Orchidaceae).
- Lecanium pseudohesperidum.
- Diaspis boisduvallii, cattleyae.
- Aspidiotus alienus, biformis-cattleyae.

CEANOTHUS (Rhamnaceae).
- Ceroputo yuccae, yuccae-ceanothi.
- Chionaspis salicis-nigrae.
- Lepidosaphes ulmi.

CEARA RUBBER (Manihot glaziovii).
- Lecanium nigrum.
- Aspidiotus destructor.

CEDRUS (Coniferae).
- Aspidiotus perniciosus, cedri, hederae.

CELTIS (Ulmaceae).
- Lecaniodiaspis celtidis.
- Lecanium subaustrale, websteri, celtium.
- Pulvinaria innumerabilis, tinsleyi, photiniae.
- Lichtensia colimensis.
- Pinnaspis siphonodontis.
- Diaspis celtidis, pentagona.
- Fiorinia fioriniae
- Aspidiotus cueroensis, ancylus, celtis.
- Parlatoria pergandei.
- Lepidosaphes mexicana, conchiformis.

CENTAUREA (Compositae).
- Gueriniella serratulae.
- Orthezia urticae.

CERASUS (Rosaceae) 'Cherry,' 'Evergreen Laurel,' etc.
KUWANINA parvus.
LECANIUM elongatum, armeniacum, caryae, cerasi, cerasifex, cerasorum, rugosum, tiliae, capreae.
CHIONASPIS furfura.
DIASPIS pentagona.
ASPIDIOTUS ancylus, forbesi, hederae, juglans-regiae, ostreaeformis, patavinus.
LEPIDOSAPHES ulmi.

CERATONIA (Leguminosae).
GUERINIELLA serratulae.
PSEUDOCOCCUS ceratoniae, citri.
LECANIUM corni.
CHIONASPIS ceratoniae.
ASPIDIOTUS hederae, aurantii, dictyospermi, britannicus.
LEPIDOSAPHES ceratoniae, ulmi

CERCIS (Leguminosae).
LECANIUM kansasense, nigrofasciatum.
ASPIDIOTUS camelliae.

CEREUS (Cactaceae).
DIASPIS echinocacti.
ASPIDIOTUS eglandulosus, hederae.

CESTRUM (Solanaceae).
ERIUM zapotlanum.
LECANIUM nocturnum.
PULVINARIA cestri.

CHAMAECYPARIS (Coniferae) 'White Cedar.'
LECANIUM pallidior.
DIASPIS visci.

CHAMAEROPS (Palmaceae).
COLOBOPYGA magnani.
RIPERSIA falcifera.
LECANIUM hesperidum.
CEROPLASTES rusci.
ASPIDIOTUS chamaeropsis, dictyospermi, hederae.
LEPIDOSAPHES pinnaeformis.

CHENOPODIUM (Chenopodiaceae).
ORTHEZIA annae.
ASPIDIOTUS chenopodii.
LEPIDOSAPHES concolor.

CHILOPSIS (Bignoniaceae).
LECANIUM chilaspidis.
ASPIDIOTUS coloratus.
LEPIDOSAPHES chilopsidis.

CHLOROPHORA (Moraceae).
LECANIUM oleae.
DIASPIS regularis.

CHRYSANTHEMUM (Compositae).
ORTHEZIA insignis.
LECANIUM oleae.
CEROPLASTES cistudiformis, rusci.
ASPIDIOTUS cydoniae-greeni, canariensis.

CHRYSOBALANUS (Rosaceae).
TACHARDIA gemmifera.
LECANIUM pseudotessellatum.

CHRYSOPHYLLUM (Sapotaceae).
ICERYA montserratensis.
LECANIUM hemisphaericum.
HOWARDIA biclavis.
ASPIDIOTUS fissidens-pluridentatus.

CINCHONA (Rubiaceae).
PSEUDOPULVINARIA sikkimensis.
LECANIUM viride, hemisphaericum, nigrum.
PULVINARIA psidii.
HOWARDIA biclavis.
ASPIDIOTUS cyanophylli, camelliae.

CINNAMOMUM (Lauraceae).
LECANIUM mangiferae, cinnamomi, pseudoleae, tessellatum.
PROTOPULVINARIA pyriformis.
CEROPLASTES rubens.
DIASPIS tubercularis.
CHIONASPIS cinnamomi, litseae.
ASPIDIOTUS articulatus, longispinus, dictyospermi, ficus, cistuloides.
PARLATORIA cinnamomi.

CISSUS (Vitaceae).
CISSOCOCCUS fulleri.
ASPIDIOTUS tesseratus.

CISTUS (Cistaceae).
ASTEROLECANIUM fimbriatum.
LECANIODIASPIS sardoa.
RIPERSIA falcifera.

CITRUS (Rutaceae) 'Orange,' 'Lemon,' etc.
PALAEOCOCCUS rosae.
ICERYA seychellarum, montserratensis, natalensis, purchasi, okadae, aegyptiaca.
ORTHEZIA insignis, praelonga.
TACHARDIA aurantiaca.
PSEUDOCOCCUS citri, filamentosus,

CITRUS (Rutaceae)—*cont.*
longispinus, lilacinus, fragilis, virgatus, nipae, bakeri, ryani, citrophilus, citriculus.
CEROPUTO yuccae, arctostaphyllii.
LECANIUM hesperidum, longulum; perlatum, viride, punctatum, townsendi, quercitronis-kermoides, tiliae, nigrum, hemisphaericum, oleae, pseudomagnoliarum, citricola, perinflatum, andersoni.
PULVINARIA aurantii, innumerabilis, mammeae, psidii, tecta, cellulosa, okitsuensis, citricola, floccifera.
CEROPLASTES ceriferus, cirripediformis, floridensis, rubens, sinensis, rusci.
TAKAHASHIA citricola.
CHIONASPIS citri, euonymi, sassceri.
HOWARDIA biclavis.
HEMICHIONASPIS aspidistrae, minor.
DIASPIS pentagona.
DINASPIS annae.
ASPIDIOTUS cydoniae, hederae, lataniae, perniciosus, duplex, albopunctatus, camelliae, trilobitiformis, ficus, articulatus, albopictus, albopictus-leonis, aurantii, koebelei, personatus, scutiformis, cocotiphagus, maskelli, dictyospermi, sylvaticus, pedroniformis, orientalis.
PARLATORIA pergandei, proteus, sinensis, ziziphus, oleae.
LEPIDOSAPHES citricola, gloveri, pallida.

CLEMATIS (Ranunculaceae).
PSEUDOCOCCUS capensis.
LECANIUM hesperidum, oleae, corni, persicae, nigrofasciatum.
ASPIDIOTUS hederae.
LEPIDOSAPHES ulmi.

CLIFFORTIA (Rosaceae).
ICERYA natalensis.
PSEUDOCOCCUS segnis.

CLUSIA (Guttiferae).
ICERYA montserratensis.
GYMNASPIS clusiae.

COBAEA (Polemoniaceae).
LECANIUM nigrum, hemisphaericum.

COCCOLOBA (Polygonaceae).
LECANIUM hesperidum.
CEROPLASTES dugesii.
ASPIDIOTUS rossi.

COCCULUS (Menispermaceae).
ICERYA seychellarum.
LEPIDOSAPHES cocculi.

COCOS (Palmaceae) 'Coconut Palm.'
ICERYA montserratensis.
ASTEROLECANIUM palmae, lineare.
PSEUDOCOCCUS cocotis, pseudonipae, virgatus, citri, nipae.
LECANIUM acutissimum, hemisphaericum, tessellatum.
PARALECANIUM cocophyllae.
CEROPLASTES actiniformis.
VINSONIA stellifera.
CHIONASPIS inday, candida.
HEMICHIONASPIS aspidistrae, minor.
PINNASPIS buxi-alba.
DIASPIS boisduvallii-cocois, vandalicus.
ASPIDIOTUS cydoniae, lataniae, palmae, destructor, ficus, aurantii, perseae, oceanica, cocotiphagus, ansei, propsimus, varians, orientalis, punicae, personatus, articulatus.
CRYPTASPIDUS nucum.
PARLATORIA greeni.
FIORINIA fioriniae.
LEPIDOSAPHES macgregori, unicolor, gloveri.

CODIAEUM (Euphorbiaceae).
PSEUDOCOCCUS crotonis, virgatus.
LECANIUM nigrum, longulum, cribrigerum.
PULVINARIA thespesiae.
ASPIDIOTUS destructor.
Cryptophyllaspis rubsaameni.
PARLATORIA proteus.
LEPIDOSAPHES newsteadi-tokionis, pinnaeformis, auriculata.

COFFEA (Rubiaceae).
ORTHEZIOLA fodiens.
ASTEROLECANIUM coffeae.
CEROCOCCUS ornatus.
STICTOCOCCUS sjostedti, gowdeyi.
PSEUDOCOCCUS citri, coffeae, filamentosus, virgatus.

COFFEA (Rubiaceae)—*cont.*
LACHNODIUS greeni.
RHIZAECUS eloti.
LECANIUM caudatum, viride, hemisphaericum, nigrum, oleae, hesperidum-javanensis, africanum, subhemisphericum.
HOWARDIA biclavis.
ASPIDIOTUS articulatus.
ISCHNASPIS longirostris.
LEPIDOSAPHES corrugata.
COLA (Sterculiaceae) 'Kola-nut.'
STICTOCOCCUS sjostedti, multispinosus, bijubatus.
LECANIUM catori.
COLEUS (Labiatae).
ORTHEZIA insignis.
PSEUDOCOCCUS citri-coleorum.
CEROPUTO barberi.
LECANIUM depressum.
CONVOLVULUS (Convolvulaceae).
PSEUDOCOCCUS virgatus.
RIPERSIA falcifera.
LECANIUM hesperidum, oleae.
CEROPLASTES rusci.
COPROSMA (Rubiaceae).
PSEUDOCOCCUS glaucus.
CTENOCHITON depressus-minor, perforatus, viridis.
INGLISIA patella.
CHIONASPIS dubia.
LEUCASPIS gigas.
POLIASPIS argentosus.
ASPIDIOTUS camelliae.
LEPIDOSAPHES pyriformis.
CORDIA (Boraginaceae).
ORTHEZIA galapagoensis.
LECANIUM mangiferae.
PULVINARIA floccifera.
PROTOPULVINARIA pyriformis.
DIASPIS cordiae.
CORDYLINE (Liliaceae).
PSEUDOCOCCUS calceolariae.
LEUCASPIS cordylinidis, stricta.
ASPIDIOTUS articulatus, dictyospermi, hederae, cyanophylli.
LEPIDOSAPHES cordylinidis.
CORNUS (Cornaceae) 'Dog-wood,' etc.
PHENACOCCUS aceris.
LECANIUM corni, tarsale, coryli.
CHIONASPIS corni, lintneri, salicis, salicis-nigrae.
ASPIDIOTUS perniciosus.
LEPIDOSAPHES ulmi.
COROKIA.
CEROCOCCUS corokiae.
INGLISIA inconspicua.
ASPIDIOTUS corokiae.
CORONILLA (Leguminosae).
ORTHEZIA urticae.
ASTEROLECANIUM fimbriatum.
ASPIDIOTUS hederae.
CORREA (Rutaceae).
SPHAEROCOCCUS floccosus.
LECANIUM hesperidum.
ASPIDIOTUS dictyospermi.
CORYLUS (Corylaceae) 'Hazel,' etc.
GOSSYPARIA spuria.
PHENACOCCUS aceris.
LECANIUM corni, corylis, corylifex, betulae, pulchrum.
ASPIDIOTUS ostreaeformis.
LEPIDOSAPHES ulmi.
CORYNEPHORUS (Gramineae).
RIPERSIA corynephori.
ERIOPELTIS festucae.
CORYNOCARPUS (Myrsinaceae).
ICERYA purchasi.
DIASPIS monserrati.
ASPIDIOTUS hederae.
COTONEASTER (Rosaceae).
LECANIUM coryli, corni, persicae.
PULVINARIA betulae.
ASPIDIOTUS perniciosus.
LEPIDOSAPHES ulmi.
COURSETIA.
ICERYA palmeri.
TACHARDIA fulgens.
ASPIDIOTUS coursetiae.
CRATAEGUS (Rosaceae) 'Hawthorn,' 'White-thorn,' etc.
ERIOCOCCUS azaleae, dearnessi.
PHENACOCCUS dearnessi.
CEROCOCCUS koebelei.
LECANIUM bituberculatum, genevense, pyri, nigrofasciatum.
PULVINARIA innumerabilis, occidentalis, oxyacanthae.
CHIONASPIS furfurus.

CRATAEGUS (Rosaceae)—*cont.*
ASPIDIOTUS forbesi, ostreaeformis, perniciosus, calurus.
LEPIDOSAPHES ulmi, ulmi-candida.
CROTALARIA (Leguminosae).
DIASPIS pentagona.
HEMICHIONASPIS minor.
CROTON (Euphorbiaceae).
ICERYA aegyptiaca, braziliensis, montserratensis, caudatum, seychellarum.
ORTHEZIA praelonga, insignis.
TACHARDIA albizziae, rubra, lacca.
PSEUDOCOCCUS longispinus, virgatus, capensis.
CEROPUTO barberi.
STICTOCOCCUS dimorphus, diversiseta.
LECANIUM hemisphaericum, nigrum.
PULVINARIA burkilli.
CEROPLASTES denudatus, ceriferus.
LICHTENSIA lutea.
ASPIDIOTUS dictyospermi, smilacis.
PARLATORIA crotonis.
LEPIDOSAPHES citricola, crotonis, lasianthi, pinnaeformis, auriculata, serrifrons.
CRUDIA.
AONIDIA biafrae.
LEPIDOSAPHES crudiae.
CRYPTOMERIA (Coniferae).
DIASPIS visci.
ASPIDIOTUS cryptomeriae.
CUPANIA (Sapindaceae).
PULVINARIA cupaniae.
ASPIDIOTUS longispinus.
CUPRESSUS (Coniferae) 'Cypress.'
ICERYA purchasi.
GUERINIELLA serratulae.
PHENACOLEACHIA zealandica.
XYLOCOCCUS macrocarpae.
SPHAEROCOCCUS cupressi.
PSEUDOCOCCUS ryani, andersoni, dudleyi, cupressi.
DIASPIS visci.
CHIONASPIS striata.
FIORINIA fioriniae.
LEUCASPIS cupressi.
ASPIDIOTUS cupressi, coniferarum-shastae.
CYANOPHYLLUM (Melastomaceae).
LECANIUM oleae.
ASPIDIOTUS cyanophylli.
CYANOTIS (Commelinaceae).
HEMICHIONASPIS aspidistrae.
ASPIDIOTUS excisus.
CYATHODES (Epacridaceae).
ERIOCOCCUS multispinus.
POLIASPIS media.
CYCAS (Cycadaceae).
PSEUDOCOCCUS longispinus, zamiae.
LECANIUM hesperidum, hemisphaericum, palmae, oleae, acutissimum.
CEROPLASTES myricae, rubens.
DIASPIS zamiae, rosae.
HEMICHIONASPIS minor.
POLIASPIS cycadis.
FIORINIA fioriniae.
ASPIDIOTUS cyanophylli, hederae, ulmi, dictyospermi, aurantii, ficus, articulatus, rossi, lataniae, orientalis, fimbriatus-capensis.
PARLATORIA proteus.
CYDONIA (Rosaceae).
TACHARDIA cydoniae, rubra, angulata.
PHENACOCCUS suwakoensis, aceris.
LECANIUM rugosum, coryli, corni, nigrofasciatum.
PULVINARIA betulae.
CEROPLASTES cirripediformis, floridensis.
CHIONASPIS furfura.
ASPIDIOTUS ancylus, cydoniae, forbesi, perniciosus, camelliae, aurantii, africanus, ostreaeformis.
LEPIDOSAPHES ulmi.
CYNODON (Gramineae).
MONOPHLEBUS fulleri.
MARGARODES mediterraneus.
ERIOCOCCUS formicicola.
CYNOMETRA (Leguminosae).
DIASPIS limuloides.
AONIDIA biafrae.
LEPIDOSAPHES aberrans, tenuior.
CYPERUS (Cyperaceae).
NEWSTEADIA floccosa.
ANTONINA australis, maritima.
PSEUDOCOCCUS sexaspinus.
LECANIUM angustatum.

CYPERUS (Cyperaceae)—*cont.*
ASPIDIOTUS cladii.
CYPRIPEDIUM (Orchidaceae).
ASTEROLECANIUM aureum.
ASPIDIOTUS dictyospermi.
CYTISUS (Leguminosae).
PSEUDOCOCCUS aridorum.
PHENACOCCUS ulicis.
LECANIUM distinguendam, corni, hesperidum.
CHIONASPIS salicis, canariensis, berlesii.
LEUCASPIS japonica.
ASPIDIOTUS camelliae, tasmaniae, hederae.
LEPIDOSAPHES ulmi.

(To be continued.)

NOTE ON THE IMMUNITY OF CHALCID PARASITES TO HYDROCYANIC ACID GAS.

By E. ERNEST GREEN.

Wishing to kill a few individuals of a species of *Lecanium*, for preservation as cabinet specimens, I subjected them to the fumes of strong hydrocyanic acid gas (in an ordinary cyanide bottle) for a period of eighteen hours. In spite of this drastic treatment, large numbers of living Chalcids emerged from the bodies of the Coccids after their removal from the killing-bottle.

This immunity of internal parasites may have a bearing upon the treatment of 'Scale Insects' in the field, when they are known to be infested by useful parasites. It would now appear to be possible to fumigate scale-infested trees, with a fair probability that any Chalcid parasites that may be developing within the bodies of the Coccids will escape—to carry on their useful work elsewhere.